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## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

### Assignment- 0

TYPE OF QUESTION: MCQ/MSQ

**Number of questions:** 15

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#### **QUESTION 1:**

Environmental engineering is related to

- a. Human health
- b. Health of earth
- c. Management of natural resources
- d. All of the above

**Correct Answer: d**

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#### **QUESTION 2:**

Demography is the study of

- a. Environmental pollution
- b. Earth ecosystem
- c. Human population
- d. geography

**Correct Answer: c**

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#### **QUESTION 3:**

Sustainability can be defined as

- a. meeting the needs of the future generation by compromising present development
- b. meeting the needs of the present generation without considering future development
- c. meeting the needs of the present generation without compromising future development
- d. None

**Correct Answer: c**



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**QUESTION 4:**

Which one is an anthropogenic source of environmental pollution?

- a. Forest fire
- b. Crop burning
- c. Rainwater harvesting
- d. Volcanic eruption

**Correct Answer: b**

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**QUESTION 5:**

What is the full form of EPA?

- a. Environmental protection agency
- b. Environmental pollution agency
- c. Earth protection agency
- d. Environmental pollution act

**Correct Answer: a**

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**QUESTION 6:**

Which of the following is/are responsible for global warming?

- a. Population Growth
- b. Deforestation
- c. Burning fossil fuel
- d. All of the above

**Correct Answer: d**

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**QUESTION 7:**

Which one can be an effective solution to control global warming?

- a. Reduce use of fossil fuel
- b. Reduce carbon emission
- c. Use of renewable energy source
- d. All of the above

**Correct Answer: d**

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**QUESTION 8:**

Which one is not a reason for soil pollution?

- a. Afforestation
- b. Industrial discharge
- c. Acid rain
- d. Agricultural activity

**Correct Answer: a**

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**QUESTION 9:**

What are the different sources of drinking water?

- a. River
- b. Groundwater
- c. Lakes
- d. All of the above

**Correct Answer: d**

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**QUESTION 10:**

What is the effective way of removing pathogenic microorganisms from water?

- a. Filtration
- b. Disinfection
- c. Sedimentation
- d. Reverse osmosis

**Correct Answer: b**

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**QUESTION 11:**

Solar energy is a source of renewable energy.

- a. True
- b. False

**Correct Answer: a**

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**QUESTION 12:**

Will e-vehicle reduce environmental pollution?

- a. True
- b. False

**Correct Answer: a**

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**QUESTION 13:**

Migration is one of the factors affecting population growth.

- a. True
- b. False

**Correct Answer: a**

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**QUESTION 14:**

Is global warming responsible for the flood?

- a. True
- b. False

**Correct Answer: a**

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**QUESTION 15:**

Biogas is a non-renewable source of energy.

- a. True
- b. False

**Correct Answer: b**

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\*\*\*\*\*END\*\*\*\*\*



## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

### Assignment- 1

TYPE OF QUESTION: MCQ/MSQ

Number of questions: 15

Total Marks  $15 \times 2 = 30$

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1.

How many 60 Watt Incandescent lamps are equivalent to three 15 Watt CFL (69)

- a. 7
- b. 22
- c. 10
- d. 21

Correct Answer:- b

Detailed Solution:



2.

Which of the following is a major greenhouse gas responsible for global warming?

- a. Carbon dioxide (CO<sub>2</sub>)
- b. Hydrogen sulphide (H<sub>2</sub>S)
- c. Carbon monoxide (CO)
- d. Oxygen (O<sub>2</sub>)

Correct Answer:- a

Detailed Solution:

- The U.S. Environmental Protection Agency and the U.S. National Academy of Sciences release reports concluding that the build-up of carbon dioxide and other "greenhouse gases" in the Earth's atmosphere will likely lead to global warming.

3.

One of the most famous and important examples of groundwater pollution in New York state (USA) is the \_\_\_\_\_.

- a. Chernobyl Accident
- b. Donora smog
- c. Cuyahoga River fire
- d. Love canal tragedy

Correct Answer:- d

Detailed Solution:

### The Love Canal Tragedy

One of the most famous and important examples of groundwater pollution in the U.S. is the **Love Canal tragedy** in Niagara Falls, New York.

1980 :[Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act \(CERCLA\)](#), better known as the Superfund Act. Love Canal became the first entry on the list



<https://blogs.roosevelt.edu/mbrinson/2013/12/01/the-1970s-and-the-love-canal-toxic-waste-community-disaster/>



4.

The effect of a defined population on the environment, including land, water and other resources is termed as \_\_\_\_\_.

- a. Ecological Fingerprint
- b. Ecological History
- c. Ecological Footprint
- d. Sustainability

Correct Answer:- c

Detailed Solution:

### Ecological Footprint

**Ecological Footprint** - the amount of land area and water required to produce sustainably the resources or ecological services needed to support a defined population at a set standard of living

- Vancouver - population 1.7 million  
ecological footprint - 19 times its area
- Netherland - 14 times its area
- Australia has one of the highest footprints at 6.25ha/person

[http://www.wwf.org.au/our\\_work/people\\_and\\_the\\_environment/  
human footprint/footprint calculator/](http://www.wwf.org.au/our_work/people_and_the_environment/human_footprint/footprint_calculator/)

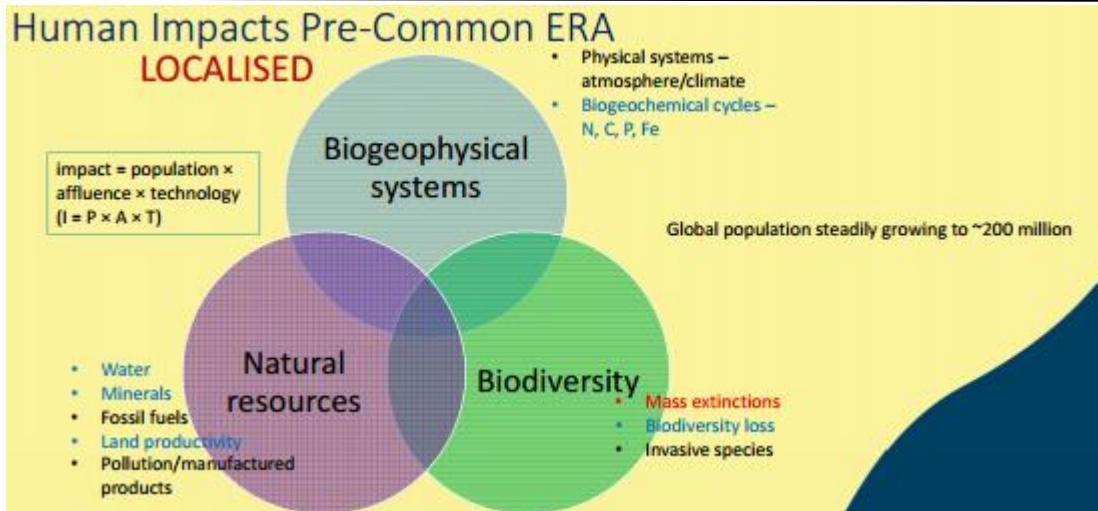
5.

Human impacts on the environmental system can be calculated by which of the following equation?

- a. Population × Affluence × Time
- b. Population × Affluence × Temperature
- c. Population × Affluence × Technology
- d. Population × Poverty × Technology

Correct Answer:- c

Detailed Solution:



6.

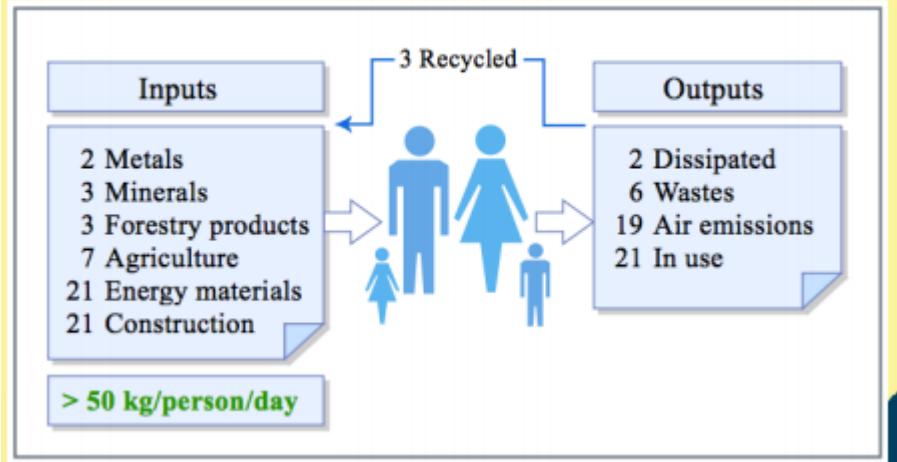
How much input of resources is required per person per day on average?

- 60 Kg
- 100 Kg
- 40 Kg
- 50 Kg

Correct Answer:- d

Detailed Solution:

### How much do you use per day?



7.

Sustainable development is \_\_\_\_\_.

- Meeting the present needs with compromising the ability of future generations
- Meeting the present needs without compromising the ability of future generations
- Using the material and resources at maximum levels
- None of these

Correct Answer:- b

Detailed Solution:

### Defining Sustainability

- **Sustainability**

Merriam –Webster definition: (1) of , relating to , or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.

- **Sustainable Development**

Brundtland Commission: Development which meets the needs of the present without compromising the ability of the future to meet its needs.

- **Sustainable Engineering** : Design of human and industrial systems to ensure that human and humankind's use of natural resources and cycles do no lead to diminished quality of life due to either to losses in future economic opportunities or to adverse impacts on social condition, human health and the environment.

8.

Match the correct options:

1. MDG 2	A. Improve maternal health
2. MDG 6	B. Global partnership for development
3. MDG 5	C. Combat diseases
4. MDG 8	D. Universal primary education

- a. 1-A, 2-B, 3-C, 4-D
- b. 1-B, 2-A, 3-D, 4-C
- c. 1-D, 2-C, 3-A, 4-B
- d. 1-C, 2-D, 3-B, 4-A

Correct Answer:- c

Detailed Solution:



9.

The most effective management intervention of water and health are \_\_\_\_\_.

- a. Provision of safe drinking water and improper disposal of human waste
- b. No provision of safe drinking water and proper disposal of human waste
- c. Provision of safe drinking water and proper disposal of human waste
- d. No provision of safe drinking water and improper disposal of human waste

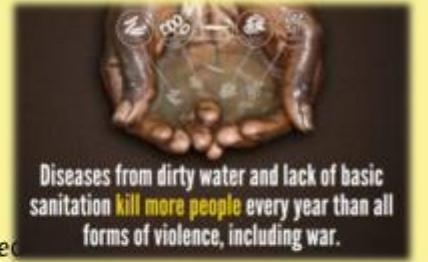
Correct Answer:- c



Detailed Solution:

## Water and Health

- 80% of diseases in developing countries are due to the lack of access to clean potable water
- Pathogens transmitted through water
  - Kill 25 million people every year by amoeba linked diarrhea, cholera, and typhoid
  - ~3,900 children die EVERY DAY (WHO, 2004)
- 90% of 2.2 million deaths of children under 5
- The most effective management intervention
  - Providing safe drinking water and proper disposal of human waste



10.

Which gas is responsible for Bhopal Gas Tragedy (1984)?

- Ethyl Isocyanate
- Methyl Isocyanide
- Hydrogen Cyanide
- Methyl Isocyanate

Correct Answer:- d

Detailed Solution:

### • 1984

- An estimated 10,000 people are killed and many more injured when Union Carbide's pesticide plant in **Bhopal, India**, leaks **40 tons of methyl isocyanate gas** into the air and sends a cloud of poison into the surrounding city of 1 million.



Select all the correct answers

11.

Identify the correct statement/statements regarding the Resource Conservation and Recovery Act (RCRA).

- a. It was enacted by Congress in 1978.
- b. The primary goal of the act is to protect human health and the environment from the potential hazards of waste disposal, conserving energy and natural resources.
- c. It focuses on waste management in the environment.
- d. It focuses on waste maximization in the environment.

Correct Answer:- b,c

Detailed Solution:



12.

Sustainable development is an integration of which of the following elements:

- a. Environment
- b. Society
- c. Energy
- d. Economy

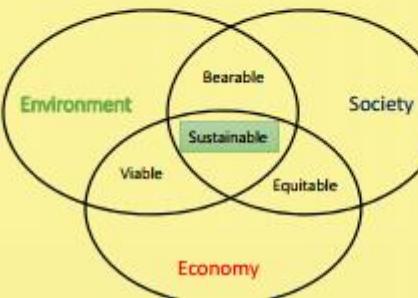
Correct answer:- a,b,d

Detailed Solution:

## Defining Sustainability

- If you Google a word sustainability or sustainable development all of the definition refer to integrating the three elements of the triple bottom line (Environment , Economy and Society).

- |                            |
|----------------------------|
| <b>Environment</b>         |
| • Materials                |
| • Biodiversity             |
| • Energy                   |
| • Biophysical interactions |
| <b>Economy</b>             |
| • Money and capital        |
| • Employment               |
| • Technological growth     |
| • Investment               |
| • Market forces            |



- |  |
|--|
| <b>Society</b>                                   |
| • Human diversity (cultural, linguistic, ethnic) |
| • Equity (dependence / independence)             |
| • Quality of life                                |
| • Institutional structures and organization      |
| • Political structures                           |

13.

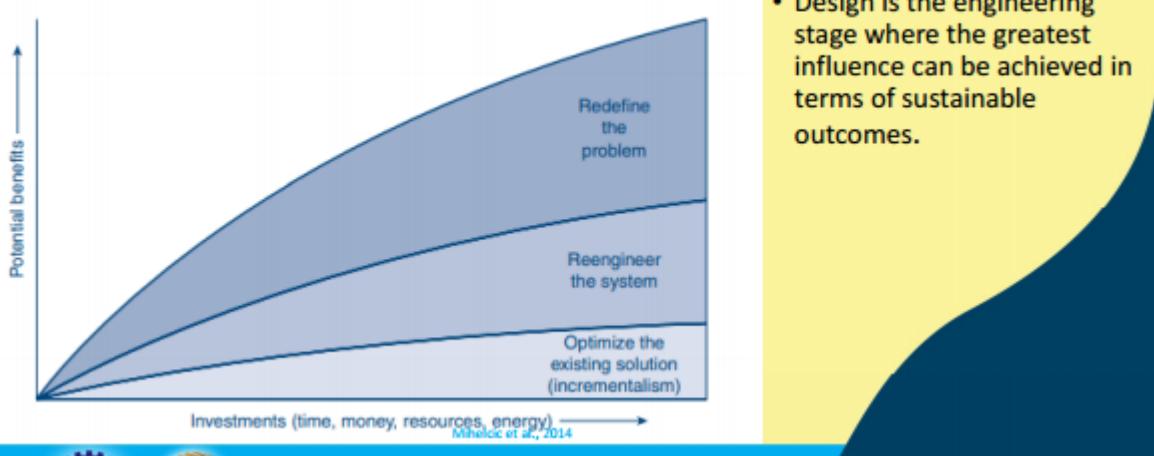
What is the potential benefit of design and innovation in advanced sustainability?

- Existing solution can be optimized
- The problem can be redefined
- The existing system can be interrupted
- A new system can be corrupted

Correct Answer:- a, b

Detailed Solution:

### Importance of design and innovation in advance sustainability



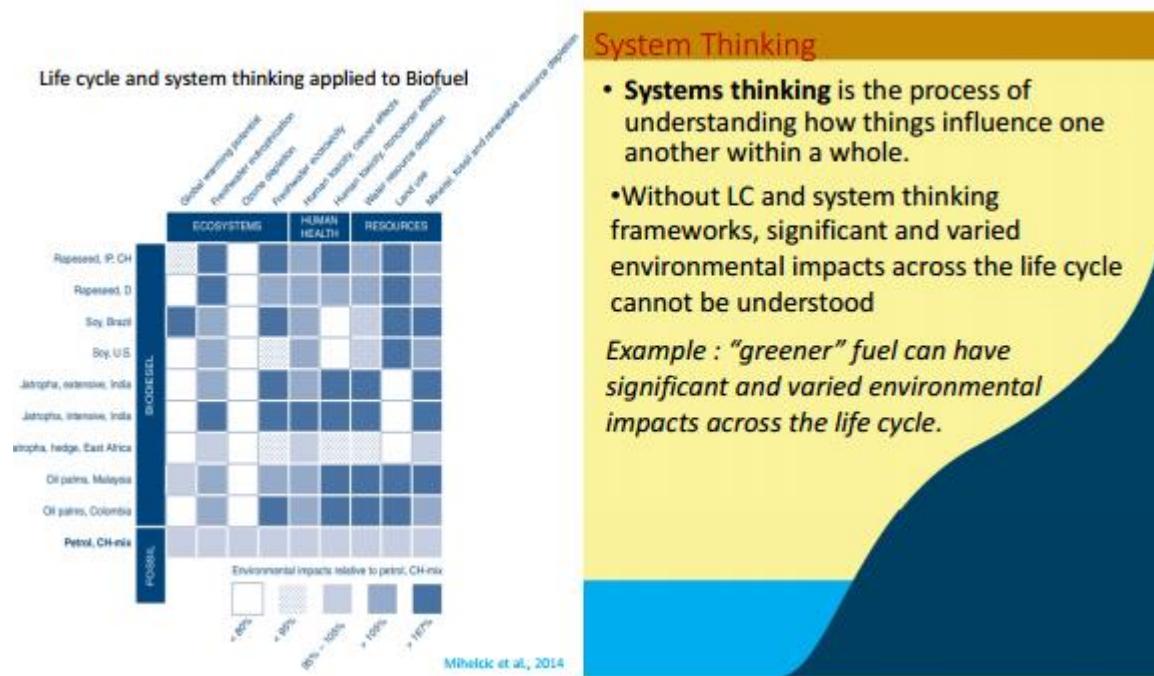
14.

Which of the following statements is/are correct?

- Systems thinking is the process of understanding how things influence one another within a whole
- In the circular economy, materials flow in a linear system
- Without LifeCycle and system thinking frameworks, significant and varied environmental impacts across the life cycle cannot be understood
- In the circular economy, materials flow in a closed-loop system

Correct Answer:- a, c, d

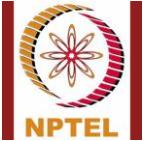
Detailed Solution:



15.

Which of the following is a principle of Green Chemistry?

- Increased use of derivatives
- Use of Renewable feedstock
- Overdue analysis for pollution prevention
- Less hazardous synthesis



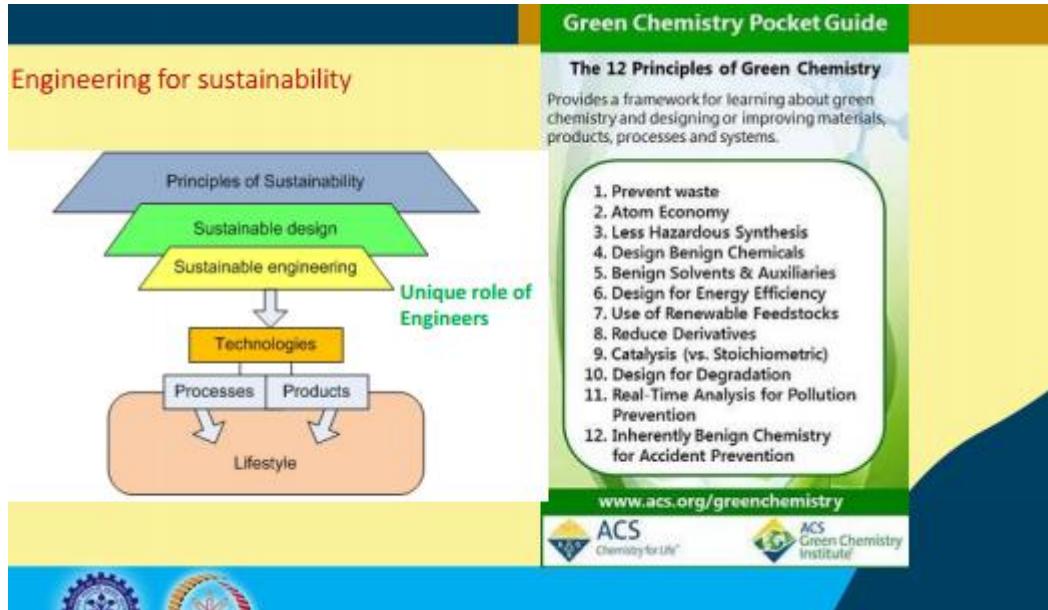
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Correct Answer:- b, d

Detailed Solution:



\*\*\*\*\*END\*\*\*\*\*



## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

### Assignment- 2

TYPE OF QUESTION: MCQ/MSQ

**Number of questions: 15**

**Total Marks 15 x 2 = 30**

#### Section 1:- Choose the correct Answer

1. 100 ml of water is analyzed and found to contain 2.0 mg of TCE. What is the TCE concentration in the water sample in mg/L?
  - a. 2 mg/L
  - b. 20 mg/L
  - c. 200 mg/L
  - d. 10 mg/L

**Correct Answer: b**

#### Detailed Solution:

Concentration of TCE =  $2\text{mg}/100\text{ ml} * 1000\text{ ml}/1\text{L} = 20\text{ mg/L}$

2. A gas mixture contains 0.005 moles of carbon monoxide (CO) and 0.995 moles of air. What is the CO concentration in air, expressed in units of ppmv?
  - a. 5 ppmv
  - b. 500 ppmv
  - c. 50 ppmv
  - d. 5000 ppmv

**Correct Answer: d**

#### Detailed Solution:

Concentration of CO in air =  $(0.005 \text{ moles of CO})/(1 \text{ mole of total air}) * 10^6 \text{ ppmv} = 5000 \text{ ppmv}$

3. The gas-phase trichloroethylene (TCE) concentration in the air above Lake Superior was 500 micrograms per cubic meter. What is the partial pressure (in atm) of TCE at STP condition?
  - a.  $8.5*10^{-8} \text{ atm}$
  - b.  $8.5*10^{-6} \text{ atm}$
  - c.  $7.5*10^{-8} \text{ atm}$
  - d.  $6.5*10^{-8} \text{ atm}$



**Correct Answer: a**

**Detailed Solution:**

We know that partial pressure = mole fraction \* total pressure

Since the system is atmosphere we take the total pressure = atmospheric pressure (1 atm)

Mole fraction =  $500 \text{ } \mu\text{g}/\text{m}^3 * \text{mole}/131.5\text{ g} * 10^{-6} \text{ g}/\mu\text{g} * 10^{-3} \text{ m}^3/\text{L} = 3.8 * 10^{-9} \text{ mole TCE/L air}$

$= 3.8 * 10^{-9} \text{ mole TCE/L air} * 22.4 \text{ L/mole air} = 8.5 * 10^{-8} \text{ mole TCE/mole air}$

Partial pressure =  $8.5 * 10^{-8} * 1 \text{ atm} = 8.5 * 10^{-8} \text{ atm.}$

4. There are two gases (A & B) present in a container and exert a pressure of 5 atm on the base of the container. If the volumetric ratio of the gases A:B is 2:3, find the partial pressure exerted by the gas A in the container?

- a. 5 atm
- b. 3 atm
- c. 2 atm
- d. 1 atm

**Correct Answer: c**

**Detailed Solution:**

Partial pressure = volumetric proportion of a gas A \* total pressure =  $2/5 * 5 = 2 \text{ atm}$

5. Which of the following gas exerts the highest partial pressure in the atmosphere?

- a. Argon
- b. Methane
- c. Carbon dioxide
- d. Oxygen

**Correct Answer: d**

**Detailed Solution:**



## Partial-Pressure Units

Table 1: Composition of the atmosphere

Gas	Volume			Source: Intergovernmental Panel on Climate Change (IPCC)
Name	Formula	in ppmv	in %	
Nitrogen	N <sub>2</sub>	780,840	78.084	
Oxygen	O <sub>2</sub>	209,460	20.946	
Argon	Ar	9,340	0.9340	
Carbon dioxide	CO <sub>2</sub>	400	0.04	
Neon	Ne	18.18	0.001818	
Helium	He	5.24	0.000524	
Methane	CH <sub>4</sub>	1.79	0.000179	



Out of the given gases, oxygen exerts more partial pressure because air contains more oxygen content when compared to the other given gases.

6. Calculate the weight of calcium hydroxide (Ca(OH)<sub>2</sub>) present in 2/3M aqueous Ca(OH)<sub>2</sub> solution?
- 23.5 g
  - 49.3 g
  - 51.2 g
  - 74.0 g

**Correct Answer: b**

**Detailed Solution:**

$$\text{Molecular weight of Ca(OH)}_2 = 40 + (16+1)*2 = 74 \text{ g}$$

Given the molarity of the solution M = 2/3

Molarity = Moles/litre

No. of moles = 2/3

1 mole = wt/molecular weight

2/3 = wt/74

$$\text{Wt.} = 2/3 * 74 = 49.3 \text{ g}$$

weight of calcium hydroxide (Ca(OH)<sub>2</sub>) present in 2/3M aqueous solution = 49.3 g



7. The strength of a solution measured as gram equivalent per litre is called \_\_\_\_\_.  
a. Molality  
b. Molarity  
c. Normality  
d. Nolality

**Correct Answer: c**

**Detailed Solution:**

## Other Types of Units

### NORMALITY

The strength of a solution measured in terms of gram equivalent per litre is called normality.

Denoted by: N

A solution having 1 g equivalent of the dissolved solute in 1 litre of its solution is called normal solution.

The solution in which  $1/10^{\text{th}}$  g equivalent of solute is dissolved per litre of its solution, is called decinormal solution i.e., the solution will have  $N/10$  strength.

Normality depends on two factors

- a) Dilution
- b) Temperature



8. Hardness and Alkalinity of water are expressed in terms of \_\_\_\_\_.  
a. mg/L of  $\text{Ca}(\text{HCO}_3)_2$   
b. mg/L of  $\text{CaCO}_3$   
c. mg/L of  $\text{MgCO}_3$   
d. mg/L of  $\text{Al}(\text{HCO}_3)_3$

**Correct Answer: b**

**Detailed Solution:**



## Other Types of Units

### Hardness

To convert the concentration of specific cations (from mg/L) to hardness (as mg/L  $\text{CaCO}_3$ ), use the following expression, where  $M^{2+}$  represents a divalent cation:

$$\frac{M^{2+} \text{ in mg}}{\text{L}} \times \frac{50}{\text{eqv wt of } M^{2+} \text{ in g/eqv}} = \text{mg/L as } \text{CaCO}_3$$

Where 50 is the equivalent weight of  $\text{CaCO}_3$

**9.** Calculate the equivalent weight of calcium bicarbonate?

- a. 81 g
- b. 162 g
- c. 101 g
- d. 40 g

**Correct Answer: a**

**Detailed Solution:**

calcium bicarbonate  $\text{Ca}(\text{HCO}_3)_2$

Molecular weight =  $40 + (1+12+48)*2 = 162$

The valency of calcium = 2

Equivalent weight = Molecular weight/valency =  $162/2 = 81$

**10.** Calculate the normality of the aqueous solution if 30 grams of sulphuric acid is mixed in 1 litre of water?

- a. 1 N
- b. 2 N
- c. 0.61 N
- d. 0.5 N

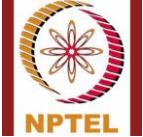
**Correct Answer: c**

**Detailed Solution:**

Molecular weight of  $\text{H}_2\text{SO}_4 = 98$

Equivalent weight of  $\text{H}_2\text{SO}_4 = 98/2 = 49$

Normality =  $30/49 = 0.61 \text{ N}$



### Section 2:- Select all the correct answers

11. Normality depends on which of the following factors?
- a. Colour of the solution
  - b. Dilution of the solution
  - c. Temperature of the solution
  - d. Odour of the solution

**Correct Answer:** b, c

**Detailed Solution:**

### Other Types of Units

#### NORMALITY

The strength of a solution measured in terms of gram equivalent per litre is called normality.

Denoted by: N

A solution having 1 g equivalent of the dissolved solute in 1 litre of its solution is called normal solution.

The solution in which  $1/10^{\text{th}}$  g equivalent of solute is dissolved per litre of its solution, is called decinormal solution i.e., the solution will have  $N/10$  strength.

Normality depends on two factors

- a) Dilution
- b) Temperature



12. Select the orthophosphates from the following.

- a.  $\text{H}_3\text{PO}_4$
- b.  $\text{H}_4\text{P}_2\text{O}_7$
- c.  $\text{H}_2\text{PO}_4^-$
- d.  $\text{HP}_3\text{O}_9^{2-}$

**Correct Answer:** a,c

**Detailed Solution:**



## Other Types of Units

- Phosphorus

Orthophosphates ( $H_3PO_4$ ,  $H_2PO_4^-$ ,  $PO_4^{3-}$ ,  $HPO_4^{2-}$ )

Polyphosphates ( $H_4P_2O_7$  and  $H_3P_3O_{10}^{2-}$ )

Metaphosphates ( $HP_3O_9^{2-}$ )

Organic phosphate



**13.** Which of the following ions are responsible for hardness in water?

- a.  $Na^+$
- b.  $CO_3^{2-}$
- c.  $Ca^{+2}$
- d.  $Al^{+3}$

**Correct Answer:** c,d

**Detailed Solution:**

Multivalent cations are responsible for hardness. In the given options, calcium and Aluminium ions are responsible for hardness in water.

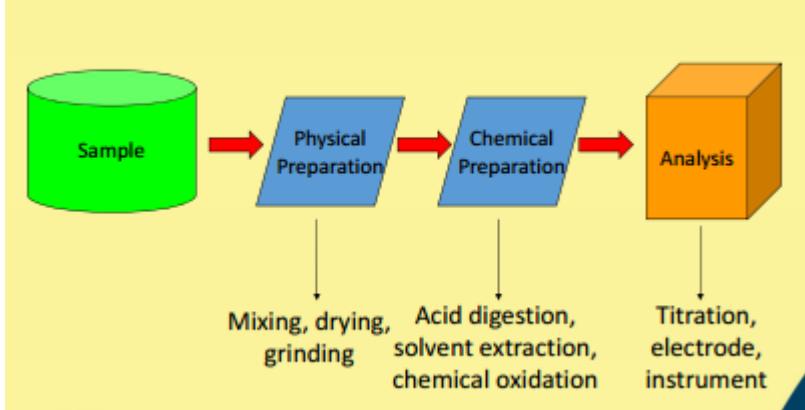
**14.** Which of the following are the different chemical preparation methods for sample analysis?

- a. Mixing
- b. Chemical oxidation
- c. Titration
- d. Acid digestion

**Correct Answer:** b, d

**Detailed Solution:**

### Sample Preparation & analysis

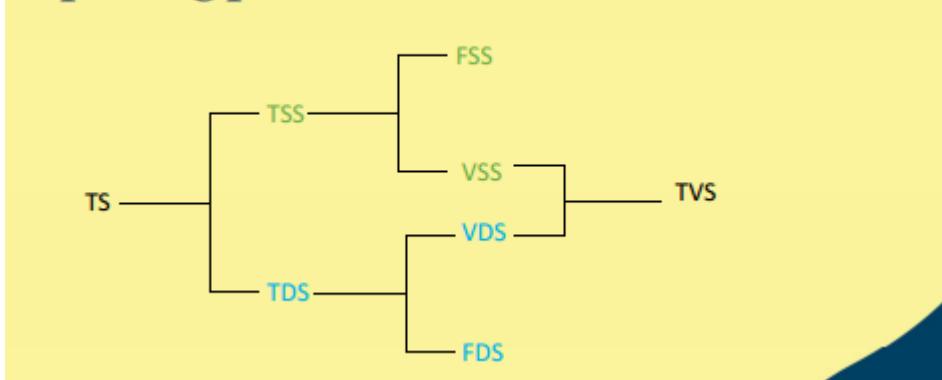


- 15.** What are the different solids components present in Total solids?
- Total Volatile Solids
  - Fixed Dissolved Solids
  - Dissolved Oxygen
  - Fixed Suspended Solids

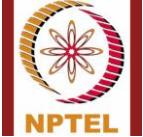
**Correct Answer:** a,b,d

**Detailed Solution:**

### Reporting particle concentrations in water



\*\*\*\*\*END\*\*\*\*\*



## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

Assignment- 3

TYPE OF QUESTION: MCQ/MSQ

**Number of questions: 15**

**Total Marks 15 x 2 = 30**

### Section 1:- Choose the correct Answer

1. What is the term for the examination of living and non-living elements and how they interact with each other?
  - a. Epidemiology
  - b. Environmental studies
  - c. Toxicology
  - d. Ecology

**Correct Answer:- b**

**Detailed Solution:-**

**What is Ecology?**  
The scientific study of interactions between different organisms and between organisms and their environment or surroundings

2. Which of the following is the kinetic equation for zero order reaction?

- a.  $[C] = [C_0] - kt$
- b.  $[C] = [C_0]*e^{-kt}$
- c.  $[C] = [C_0]*kt$
- d.  $[C] = [C_0] \ln(kt)$

**Correct Answer:- a**

**Detailed Solution:-**

## ZERO-ORDER AND FIRST-ORDER REACTIONS

$C \rightarrow \text{products}$

$$d[C]/dt = -k[C]^n \dots\dots\dots(1)$$

### ZERO-ORDER REACTION

$$d[C]/dt = -k \dots\dots\dots(2)$$

Reaction Order	Rate Law	Integrated form of Rate Law	Plot of Concentration versus Time	Linearized Plot of Concentration versus Time	Half-Life, $t$	Example Units of Rate Constant, $k$
<b>Zero</b>	$\frac{d[C]}{dt} = -k$	$[C] = [C_0] - kt$		Same as [C] vs. time	$\frac{0.5[C_0]}{k}$	moles/L-s mg/L-s
<b>First</b>	$\frac{d[C]}{dt} = -k[C]$	$[C] = [C_0]e^{-kt}$			$\frac{0.693}{k}$	s <sup>-1</sup> , min <sup>-1</sup> , h <sup>-1</sup> , day <sup>-1</sup>

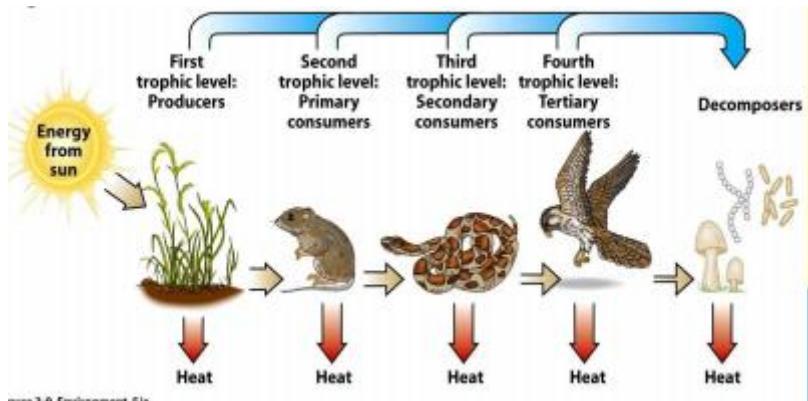
3. Match the following.

i. Producers	a. Animals
ii. Consumers	b. Bacteria, fungi
iii. Decomposers	c. Plants

- a. i) a, ii) c, iii) b.
- b. i) c, ii) b, iii) a.
- c. i) b, ii) c, iii) a.
- d. i) c, ii) a, iii) b.

Correct Answer:- d

Detailed Solution:-



**4.** What do decomposers consume for sustenance?

- a. Animals
- b. Plants
- c. Dead Organisms/Animals
- d. Grass

**Correct Answer:- c**

**Detailed Solution:-**

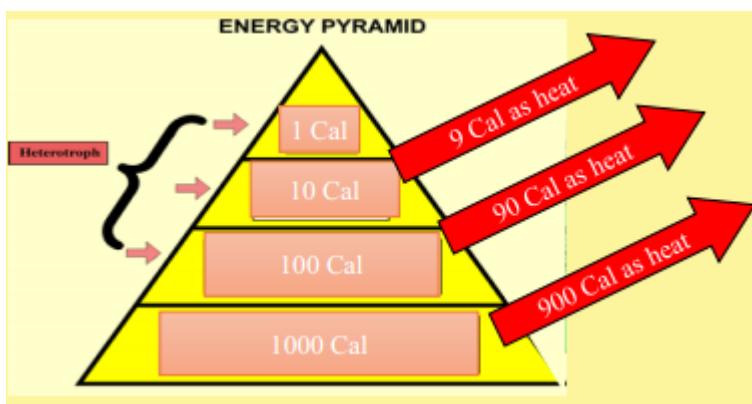
A Decomposer is **an organism that mostly consumes decaying biomass**.

**5.** The amount of energy available for higher trophic levels on the energy pyramid is \_\_\_\_\_ than the amount of energy at lower trophic levels of the energy pyramid.

- a. Higher
- b. No change on
- c. Lower
- d. Medium

**Correct Answer:- c**

**Detailed Solution:-**



**6.** Consider the following food chain which occurs in a forest:

Grass → Deer → Lion

If 3750 joules of solar energy is available to the grass, how much energy would the lion get by eating the Deer?

- a. 3750 Joules



- b. 375 Joules
- c. 37.5 Joules
- d. 3.75 Joules

**Correct Answer:- d**

**Detailed Solution:-**

Since the lion is at the third trophic level, according to the 10% law, the lion will get  
 $0.1 * 0.1 * 0.1 * 3750 = 3.75$  joules

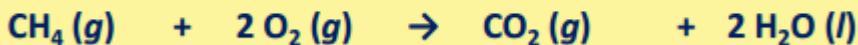
**7. Calculate the stoichiometric requirement of O<sub>2</sub> to burn 2gram of methane gas completely?**

- a. 4 g of O<sub>2</sub>
- b. 64 g of O<sub>2</sub>
- c. 16 g of O<sub>2</sub>
- d. 8 g of O<sub>2</sub>

**Correct Answer:- d**

**Detailed Solution:-**

The balanced equation is as follows



16 g of methane requires 64 g of O<sub>2</sub>; hence 2g of methane requires 8 g of O<sub>2</sub>.

- 8. A town had a population of 300,000 at the end of 2010. Suppose in the year 2020 there were 6000 births and 4500 deaths. And in the same year, there were 1500 emigrants and 500 immigrants. Calculate the percentage of population increase only due to birth in 2020.**
- a. 2%
  - b. 2.5%
  - c. 3%
  - d. 3.2%

**Correct Answer:- a**



**Detailed Solution:-**

percentage of population increase due to birth in 2020 = Births/Initial Population

$$= 6000/300000 = 0.02*100$$

$$= 2\%$$

**9.** A town had a population of 300000 at the end of the year 2010. Suppose in the year 2020 there were 6000 births and 4500 deaths. And in the same year, there were 1500 emigrants and 500 immigrants. Calculate the net population growth rate in 2020.

- a. 0.167%
- b. 0.23%
- c. 0.315%
- d. 0.142%

**Correct Answer:- a**

**Detailed Solution:-**

$$r = (6000-4500) + (500-1500) = 500$$

$$500/300000 = 1.66 \times 10^{-3} \times 100 = 0.167\%$$

**10.** What is the global biocapacity of Australia?

- a. 8.00 gha/person
- b. 0.04 gha/person
- c. 1.7 gha/person
- d. 6.84 gha/person

**Correct Answer:- d**

**Detailed Solution:-**



## Ecological Footprint

**Ecological Footprint - the impact of a person or community, of a set standard of living, on the environment, expressed as the amount of land/water required to sustain their use of natural resources**

(lower the better!)

- World global bio-capacity – 1.7gha/person!
- USA – 8.00gha/person
- Puerto Rico – 0.04gha/person
- Australia - 6.84gha/person

One global hectare (gha) represents the average productivity of all biologically productive areas (measured in hectares) on earth in a given year.

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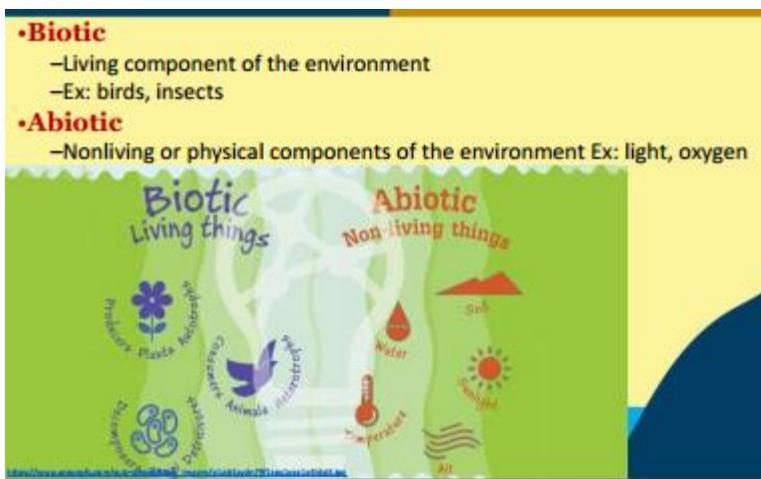
### Section 2:- Select all the correct answers

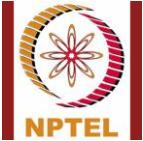
11. Which of the following are the biotic components of the ecosystem?

- a. Water
- b. Plants
- c. Humans
- d. Atmospheric Pressure

Correct Answer:- b,c

Detailed Solution:-





12. Which of the following different environmental chemistry approaches are used to evaluate the chemical's fate and treatment?
- Entropy
  - Chemical kinetics
  - Gibbs free energy
  - Chemical equilibrium

**Correct Answer:- b,d**

**Detailed Solution:-**

### Approaches in Environmental Chemistry

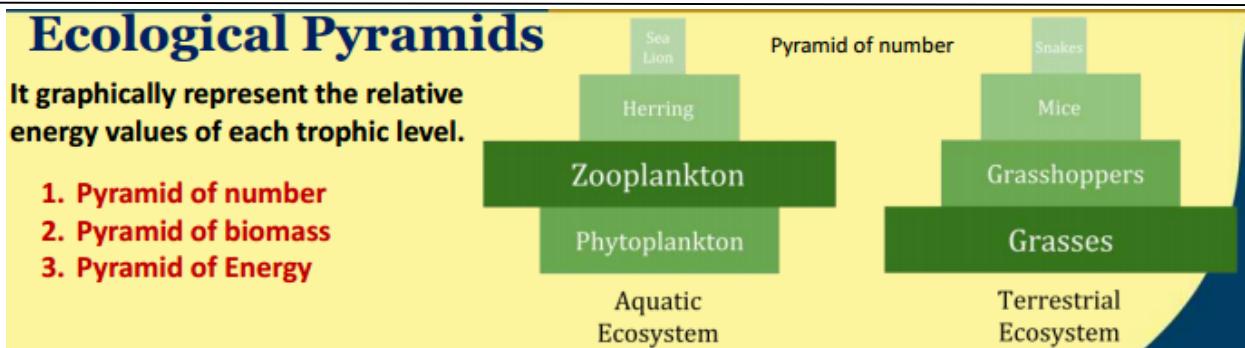
- Chemistry is the study of the composition, reaction, and characteristics of matter. It is important because the ultimate fate of many chemicals discharged to air, water, and treatment facilities is controlled by their reactivity and chemical speciation.
- Two different approaches are used in evaluating a chemical's fate and treatment: **Kinetic and Equilibrium**.
- Kinetic deals with rate of reactions**
- Equilibrium deals with the final results**

13. Which of the following is a type of Ecological pyramid?

- The pyramid of numbers
- The pyramid of carbon
- The pyramid of biomass
- The pyramid of energy

**Correct Answer:- a, c, d**

**Detailed Solution:-**

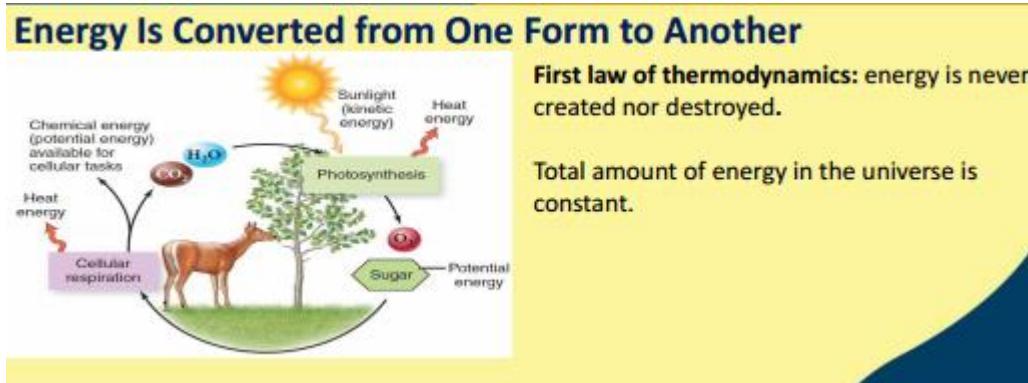


14. Which law states that “Energy can neither be created nor be destroyed”?

- a. Second law of thermodynamics
- b. First law of thermodynamics
- c. Law of conservation of energy
- d. Law of conversation of mass

**Correct Answer:- b,c**

**Detailed Solution:-**



Law of conservation of energy states that energy can neither be created nor be destroyed.

15. Which of the following statements are correct, corresponding to poverty?

- a. The United Kingdom has 17% poverty.
- b. The poor are most exposed to environmental pollution.
- c. 80% of the annual victims of air pollution are rural poor in developing countries

d. The US had 14% poverty in 2014.

**Correct Answer:- b,c**

**Detailed Solution:-**

## Poverty in Developed Countries

- **7-17% in developed nations are poor**
- **Sweden (7%) is 13th in average income**
- **The US has the highest average income and the highest poverty (17%)**
- **The UK has 14.3% poverty and the Netherlands 7% poverty with the same income levels**
- **Australia had 13.9% poverty in 2014**



## Pollution and the Poor

- **Generally the poor are most exposed to pollution**
- **80% of the 2.7 million annual victims of air pollution are rural poor in developing countries**
- **Lead poisoning is affecting child development in developing countries; in Bangkok up to 70,000 children lose 4 or more IQ points due to atmospheric lead**
- **In Latin America up to 15 million children under 2 are at similar risks**
- **In China, chemical plants are causing soil, air and water pollution in rural areas, increasing rates of cancer and respiratory disease**



## Introduction to Environmental Engineering and Science – Fundamentals and Sustainability Concepts

### Assignment- Week 4

1. Which of the following statements is true?

- a. Mass flux is the flow of mass per unit area
- b. Mass flux is only positive in nature
- c. Mass flux can be both positive and negative
- d. None

**Correct Answer:- c**

**Detailed Solution:-**

### Mass Balances

#### Mass flux

- The rate at which mass enters and leaves the system.

When  $\Delta t \rightarrow 0$

$$\begin{aligned} (\text{mass accumulation rate}) &= (\text{mass flux in}) - (\text{mass flux out}) \\ &\quad + (\text{Net rate of chemical production}) \end{aligned}$$

$$\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out} + \dot{m}_{reaction}$$

$\dot{m}$  = mass flux with units of mass/time



2. What is the full form of CMBR?

- a. Continuously mixed batch reactor
- b. Completely mixed batch reactor
- c. Completely mixed bulk reactor
- d. Continuously mixed bulk reactor

**Correct Answer:- b**

**Detailed Solution:-**

## Reactor design

Mode of operation

Reactor kinetics

- 1. Batch reactor/ Completely mixed batch reactor (CMBR)
- 2. Continuous reactor/continuous stirred tank reactor (CSTR)
- 3. Plug flow reactor

- 1. Reaction order zero
- 2. First order reaction
- 3. Second order reaction



3.

Match the following energy to its correct formula -

1.	Gravitational energy	i)	$(\text{Mass} \times \text{velocity}^2)/2$
2.	Chemical internal energy	ii)	$\text{Mass} \times \text{change in height}$
3.	Heat internal energy	iii)	$\Delta H_{\text{reaction}}$ at constant time
4.	Kinetic energy	iv)	$\text{Mass} \times \text{heat capacity} \times \text{change in temperature}$

- a. 1(ii), 2(iii), 3(i), 4(iv)
- b. 1(ii), 2(iii), 3(iv), 4(i)
- c. 1(i), 2(iii), 3(iv), 4(ii)
- d. 1(iv), 2(ii), 3(i), 4(iii)

**Correct Answer:- b**

**Detailed Solution:-**

## Energy Balances

### Common forms of energy: calculation formula

Energy	Formula
Heat internal energy	$\Delta E = \text{mass} \times \text{Heat capacity (c)} \times \Delta T$
Chemical internal energy	$\Delta E = \Delta H_{\text{reaction}}$ at constant time
Gravitational energy	$\Delta E = \text{mass} \times \Delta \text{ height}$
Kinetic energy	$E = \text{mass} \times \text{velocity}^2/2$
Electromagnetic energy	$E = \text{Planck's constant} \times \text{photon frequency}$



4. The governing equation for CMBR is

- a.  $\frac{dm}{dt}_{\text{net}} = \dot{m}_{in} + \dot{m}_{out} + \dot{m}_{reaction}$
- b.  $\frac{dm}{dt}_{\text{net}} = \dot{m}_{reaction}$
- c.  $\frac{dm}{dt}_{\text{net}} = \dot{m}_{in} - \dot{m}_{out}$
- d.  $\frac{dm}{dt}_{\text{net}} = \dot{m}_{in} - \dot{m}_{reaction}$

**Correct Answer:- b**

**Detailed Solution:-**

## **Batch reactor/ Completely mixed batch reactor (CMBR): Reaction order zero**

Fundamental equation of mass balance in CMBR  $\frac{dm}{dt} = \dot{m}_{in} - \dot{m}_{out} + \dot{m}_{reaction}$

For batch reactor have no inputs or outputs

$$\frac{dm}{dt}_{net} = \frac{\dot{m}_{in} - \dot{m}_{out}}{m} = \frac{dm}{dt}_{reaction}$$

For zero order reaction  $\frac{dm}{dt}_{net} = -k$

$$\int_{C_0}^{C_e} dc = \int_0^t -k dt$$

$$[C_e - C_0] = -kt$$

$$C_e = C_0 - kt$$



5. Which of the following statements is/are correct?

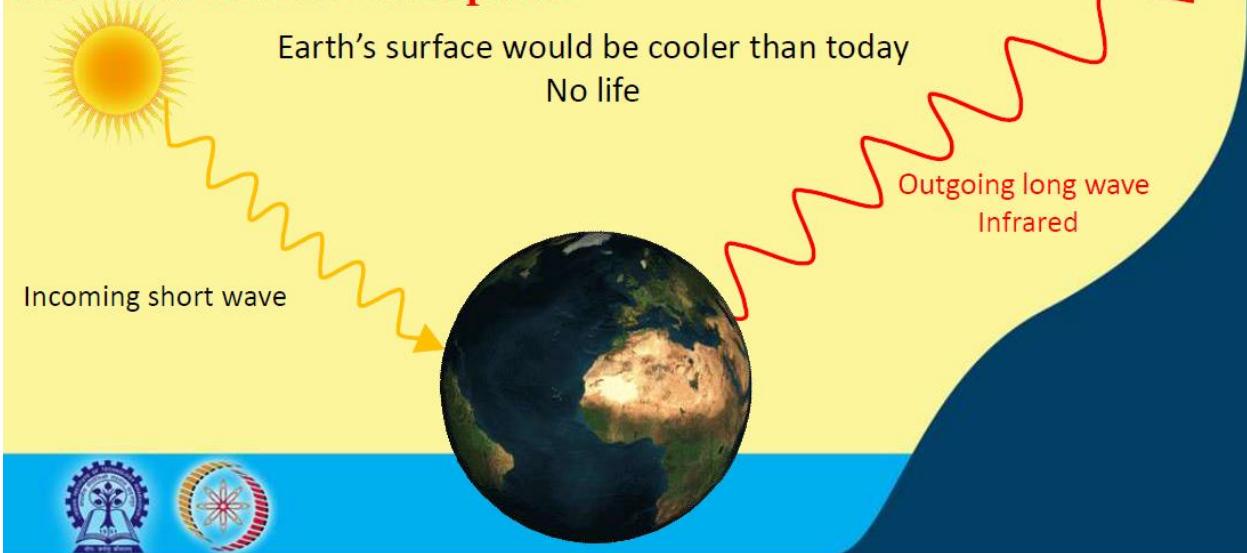
- a. Without atmosphere earth's surface would be cooler than today
- b. Without atmosphere earth's surface would be hotter than today
- c. The temperature of earth's surface does not depend on the atmospheric presence
- d. None of these

**Correct Answer:- a**

**Detailed Solution:-**

## Energy balance of Earth

### The earth with no atmosphere



6. Which one is not a greenhouse gas?

- a. Methane
- b. Nitrogen dioxide
- c. Water vapor
- d. argon

**Correct Answer:- d**

**Detailed Solution:-**

## What is a Greenhouse Gas?

A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range. Greenhouse gases cause the greenhouse effect.

- Some examples:

Water vapor



Carbon dioxide

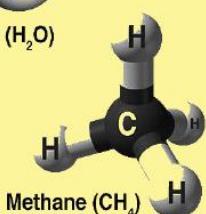
Nitrous oxide ( $\text{N}_2\text{O}$ )



Nitrous oxide



Methane



7. which one is the correct formula for first-order reaction kinetics in CSTR?

- a.  $c_{out} - c_0 = \frac{kV}{Q}$
- b.  $c_{out} - c_0 = -\frac{kV}{Q}$
- c.  $c_{out} = c_0(1 + \frac{kV}{Q})$
- d.  $c_{out} = c_0/(1 + \frac{kV}{Q})$

**Correct Answer:- d**

**Detailed Solution:-**

## Continuous stirred tank reactor (CSTR): First order reaction

$$0 = \dot{m}_{in} - \dot{m}_{out} + \left(\frac{dm}{dt}\right)_{reaction} V$$
$$\dot{m}_{in} = QC_0$$
$$\dot{m}_{in} = QC_{out}$$

For first order reaction  $\frac{dm}{dt}_{net} = -kC_{out}$

$$0 = QC_0 - QC_{out} - kC_{out}V$$
$$QC_0 - QC_{out} = kC_{out}V$$
$$C_0 = C_{out} + kC_{out}V/Q$$
$$C_{out} = C_0 / \left(1 + \frac{kV}{Q}\right)$$



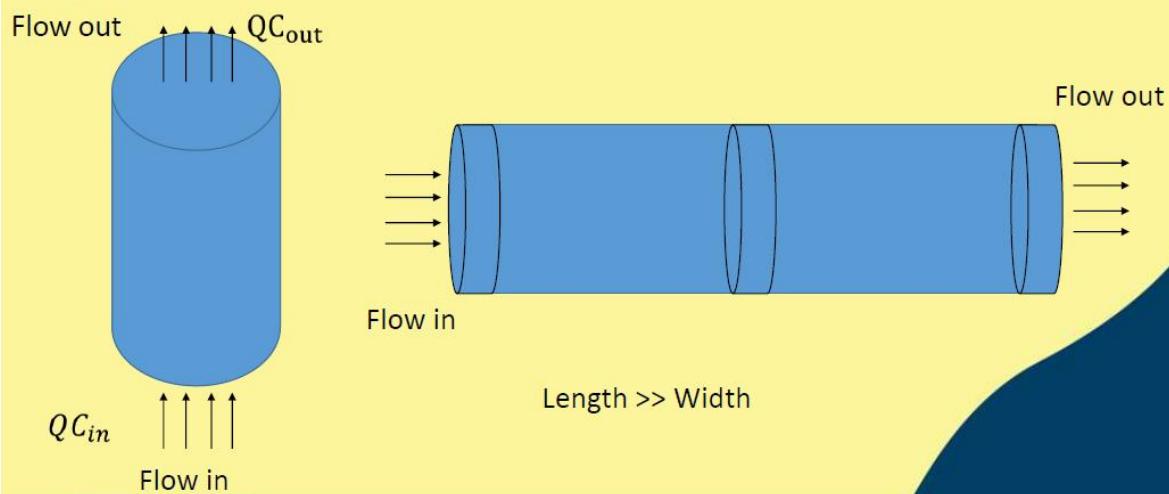
8. Which of the following is true regarding plug flow reactor

- a. Length = width
- b. Length  $\gg$  width
- c. Length  $\ll$  width
- d. None

**Correct Answer:- b**

**Detailed Solution:-**

### Plug Flow Reactor (PFR)



9. Calculate the HRT of a CSTR of volume 100 m<sup>3</sup> operating at a hydraulic loading of 20 m<sup>3</sup>/hr

- a. 1 day
- b. 2 h
- c. 4 days
- d. 5 h

**Correct Answer:- d**

**Detailed Solution:-**

### Reaction HRT

$$\Theta = V/Q$$

$V = 300 \text{ m}^3$  and  $Q = 25 \text{ m}^3/\text{day}$ .  $\text{HRT} = 100/20 = 5 \text{ hours}$

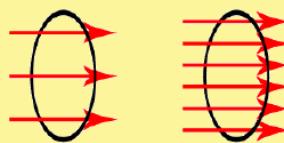
10. What is the correct unit of mass flux density?

- a. g.s<sup>-1</sup>.m<sup>2</sup>
- b. g.s.m<sup>-2</sup>
- c. g.s<sup>-1</sup>.m<sup>-2</sup>
- d. g.s<sup>-2</sup>.m<sup>-1</sup>

**Correct Answer:- c**

**Detailed Solution:-**

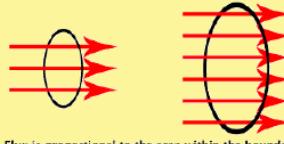
## Mass Flux Density



Flux is proportional to the density of flow.



Flux varies by how the boundary faces the direction of flow.



Flux is proportional to the area within the boundary.

Mass flux density is defined as the rate of mass transferred across the plane per unit time per unit area. The symbol  $J$  will be used to represent the flux density, expressed as the rate per unit area at which mass is transported across an imaginary plane.  $J$  has units of (mass/time-length squared).



\*\*\*\*\*Select all the correct answers\*\*\*\*\*

11. Which of the following statements is/are correct?

- a. CMBR operates in batch mode
- b. CMBR operates with a continuous inflow of mass
- c. Liquid content is uniformly mixed in CMBR
- d. CMBR is one of the complex reactor types

**Correct Answer:- a, c**

**Detailed Solution:-**

## **Batch reactor/ Completely mixed batch reactor (CMBR)**

- The simplest reactor type
- Flow is neither entering nor leaving the reactor
- The liquid contents are mixed completely and uniformly

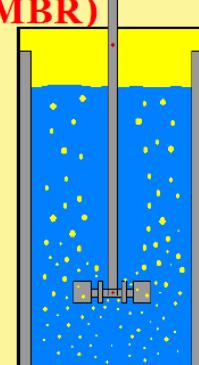


## **Batch reactor/ Completely mixed batch reactor (CMBR)**

Batch reactors are used in a number of industries producing small quantities of high-valued materials such as cell cultivation,

polymer synthesis  
and crystallization.

To operate the batch reactor with success, the final quality performance has to maintain with minimum cost. Though operated with the same recipe, the batch process shows batch-to-batch variations in its specified trajectories. Therefore, online process monitoring is essential to achieve successful batch operation.



12. Which of the following statements is/are correct?

- a. The control volume is a temporal region
- b. The control volume is a fixed volume of 1 L
- c. The control volume is a spatial region
- d. The control volume has boundaries

**Correct Answer:- c, d**

**Detailed Solution:-**

# Mass Balances

## Control volume

- A mass balance is useful only in terms of a specific region of space, which has boundaries across which the terms  $\dot{m}_{in}$  and  $\dot{m}_{out}$  are determined. This region is called control volume.
- Theoretically volume of any shape and location can be used as control volume. The most important attribute of a control volume is that it has boundaries over which  $\dot{m}_{in}$  and  $\dot{m}_{out}$  can be calculated.

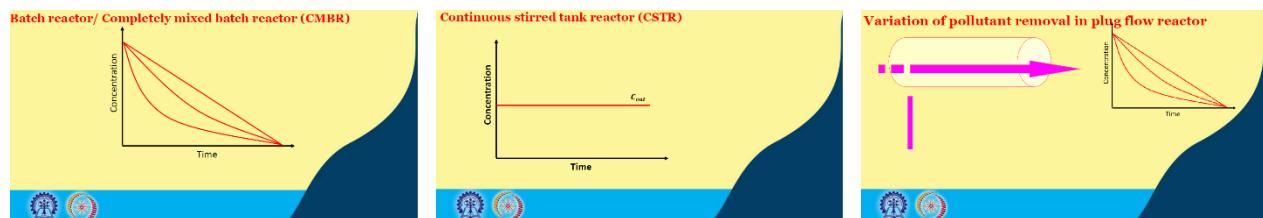


13. Which of the following statements is/are correct?

- Reactant concentration inside the reactor varies with time in CSTR
- Reactant concentration inside the reactor varies with time in CMBR
- Reactant concentration inside the reactor varies with time in PFR
- Reactant concentration inside the reactor does not vary with time in CSTR

**Correct Answer:- b, c**

**Detailed Solution:-**



14. Which of the following options related to energy balance is/are correct?

- The total energy of an isolated system is constant
- Change in internal energy of a closed system is equal to the work done by the system on the surroundings
- Change in internal energy of a closed system is equal to the amount of heat supplied to the system, minus the work done by the system on the surroundings
- The total energy of an isolated system is not constant

**Correct Answer:- a, c**

**Detailed Solution:-**

## Energy Balances

### Why is it necessary to do energy balance?

The first law of thermodynamics is a version of the law of conservation of energy, adapted for thermodynamic systems. The law of conservation of energy states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but can be neither created nor destroyed. The first law is formulated as

$$\Delta U = Q - W$$

It states that the change in the internal energy  $\Delta U$  of a closed system is equal to the amount of heat  $Q$  supplied to the system, minus the amount of work  $W$  done by the system on its surroundings



15. which of the following statements is/are correct?

- a. advective transport is related to flow velocity
- b. Reynold's number is used to predict the fluid flow pattern
- c. mechanical dispersion is related to the randomness of fluid molecules
- d. turbulent diffusion is due to the random fluctuation in the advective velocity

**Correct Answer:- a, b, d**

**Detailed Solution:-**

## Reynold's number

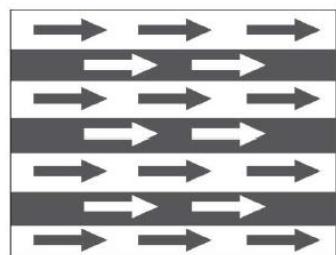
The **Reynolds number (Re)** is an important dimensionless quantity in fluid mechanics used to help predict flow patterns in different fluid flow situations.

At low Reynolds numbers, flows tend to be dominated by laminar (sheet-like) flow, while at high Reynolds numbers turbulence results from differences in the fluid's speed and direction, which may sometimes intersect or even move counter to the overall direction of the flow (eddy currents).

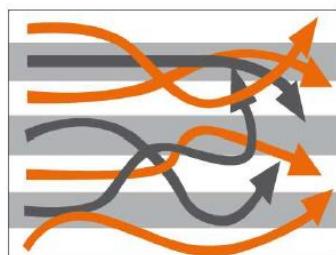


## Turbulent Dispersion

Basically turbulent diffusion is due to random fluctuation in advective velocity. A typical one dimensional velocity history at a single point in a turbulent velocity field might look like the figure below.



Homogeneous flow



Turbulent flow

VS



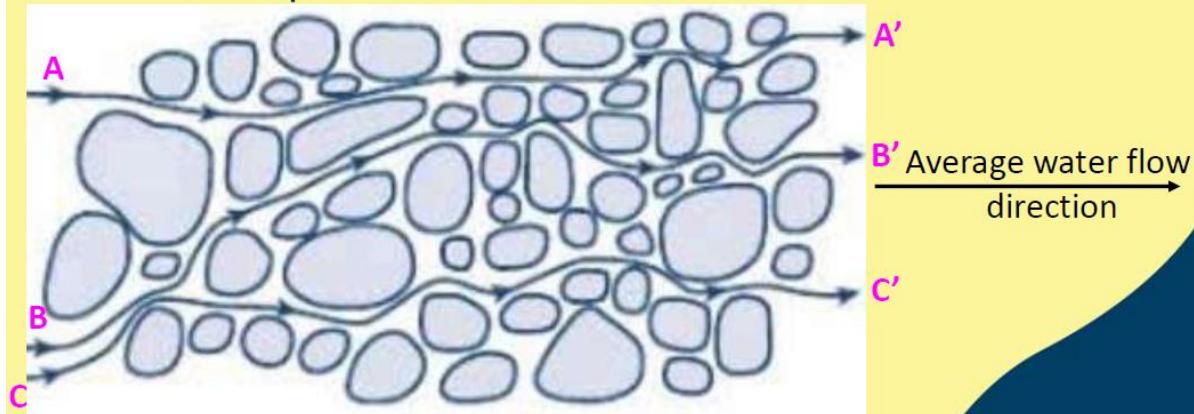
# Mass Transport processes

## Advection

Advection refers to transport with the mean fluid flow. For example, if the wind is blowing toward the east, advection will carry any pollutants present in the atmosphere toward the east. Similarly, if a bag of dye is emptied into the center of a river, advection will carry the resulting spot of dye downstream. In contrast, dispersion refers to the transport of compounds through the action of random motions.



## Mechanical Dispersion



Introduction to Environmental Engineering and Science – Fundamentals and Sustainability Concepts

Assignment- Week 5

Section 1 : Choose the correct answer

1. What is the correct abbreviation of BOD?
  - a. Biological oxygen demand
  - b. Biochemical oxygen demand
  - c. Bio-geochemical oxygen demand
  - d. None

Correct Answer:- b

Detailed Solution:-

## Oxygen Demand

**Biochemical oxygen demand or BOD** is a chemical procedure for determining the amount of dissolved **oxygen** needed by aerobic **biological** organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.

**Aerobic decomposition**  
Organic matter +O<sub>2</sub>  $\xrightarrow{\text{Microbes}}$  CO<sub>2</sub>+H<sub>2</sub>O +New cells + Stable products(NO<sub>3</sub>,PO<sub>4</sub>,SO<sub>4</sub>)

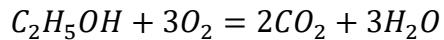
**Aerobic decomposition**  
Organic matter  $\xrightarrow{\text{Microbes}}$  CO<sub>2</sub>+H<sub>2</sub>O +New cells + Unstable products(H<sub>2</sub>S, NH<sub>3</sub>,CH<sub>4</sub>)



2. What is the ThOD for 30 mg/L of ethanol (C<sub>2</sub>H<sub>5</sub>OH) in an aquatic system?
  - a. 72.5 mg O<sub>2</sub>/L
  - b. 98.4 mg O<sub>2</sub>/L
  - c. 32.6 mg O<sub>2</sub>/L
  - d. 62.6 mg O<sub>2</sub>/L

Correct Answer:- d

Detailed Solution:-



ThOD = (3 moles of O<sub>2</sub>)/1 mole of C<sub>2</sub>H<sub>5</sub>OH × (32 g O<sub>2</sub>)/1 mole O<sub>2</sub> × (1 mole C<sub>2</sub>H<sub>5</sub>OH)/(46 g C<sub>2</sub>H<sub>5</sub>OH) × 30 mg/L of C<sub>2</sub>H<sub>5</sub>OH

= 62.6 mg O<sub>2</sub>/L

3. Which one is the correct formula for BOD<sub>5</sub> of wastewater?

- a.  $BOD_5 = (DO_i - DO_f)/p$
- b.  $BOD_5 = (DO_f - DO_i)/p$
- c.  $BOD_5 = (DO_i - DO_f)p$
- d.  $BOD_5 = (DO_f - DO_i)p$

Correct Answer:- a

Detailed Solution:-

$$\bullet BOD_5 = DO_i - DO_f / P$$

DO<sub>i</sub> = Initial dissolved oxygen

DO<sub>f</sub> = Final dissolved oxygen (after days)

P = Dilution factor = Volume of wastewater / volume of wastewater + dilution water



4.

25 mL of wastewater sample is mixed with dilution water to make a total volume of 300 mL. It is desirable to have at least 2 mg/L DO drop during the 5-day test. What is the minimum detectable BOD<sub>5</sub> with this dilution?

- a. 30 mg/L
- b. 12 mg/L
- c. 24 mg/L
- d. 6 mg/L

Correct Answer:- c

Detailed Solution:-

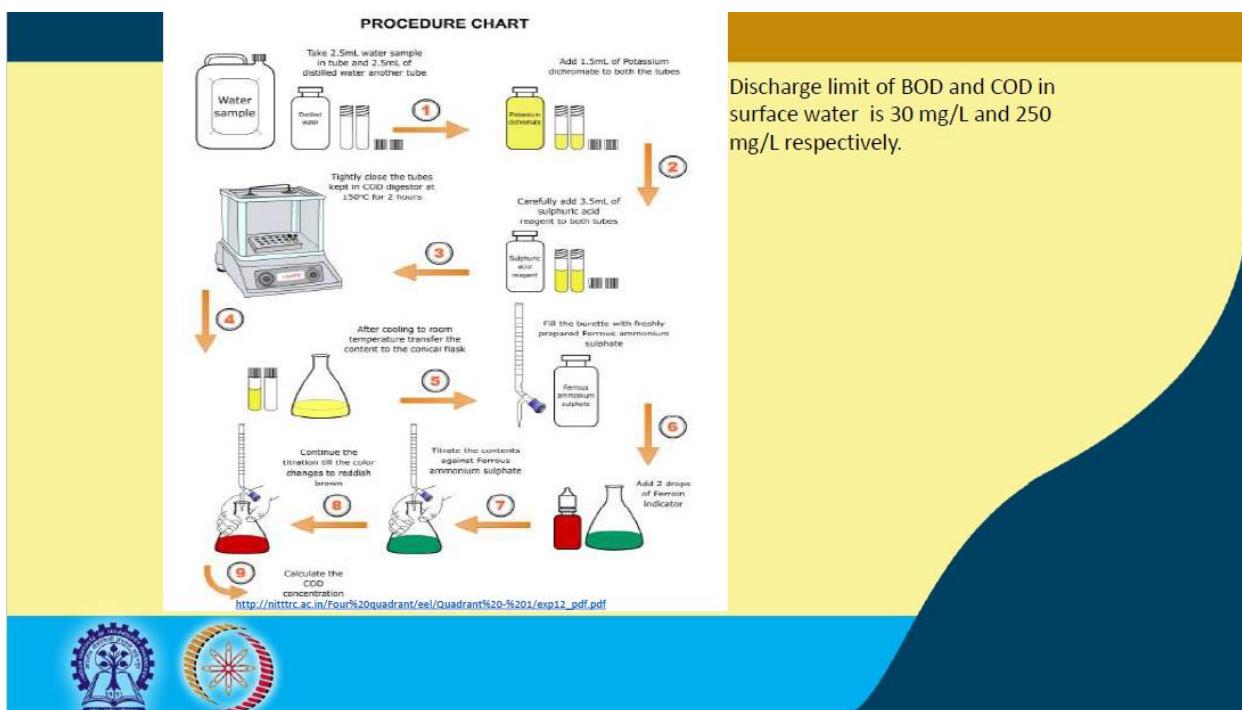
The dilution fraction is  $p = 25/300$ . To get at least a drop of 2 mg/L in DO during the 5 day run, the minimum BOD<sub>5</sub> needs to be  $= (\text{DO}_i - \text{DO}_f)/p = 2/(25/300) = 24 \text{ mg/L}$

5. What is the correct approach for COD analysis of a wastewater sample?

- a. Digestion time for COD is 30 min
- b. Digestion temperature for COD is 150 °C
- c. Methyl blue is used as an indicator in COD analysis
- d. During titration, color changes from reddish-brown to green

Correct Answer:- b

Detailed Solution:-



6. What pathways facilitate the transfer of pollutants from the environment to the human body?

- a. Inhalation
- b. Ingestion
- c. Absorption
- d. All of the above

Correct Answer:- d

Detailed Solution:-

# **Environmental Health Science**

- The study of those factors in the environment that affect human health the environment
  - Pollutants in air, water and soil which are transferred to humans by inhalation, ingestion, or absorption.
  - Which results in adverse health effects.



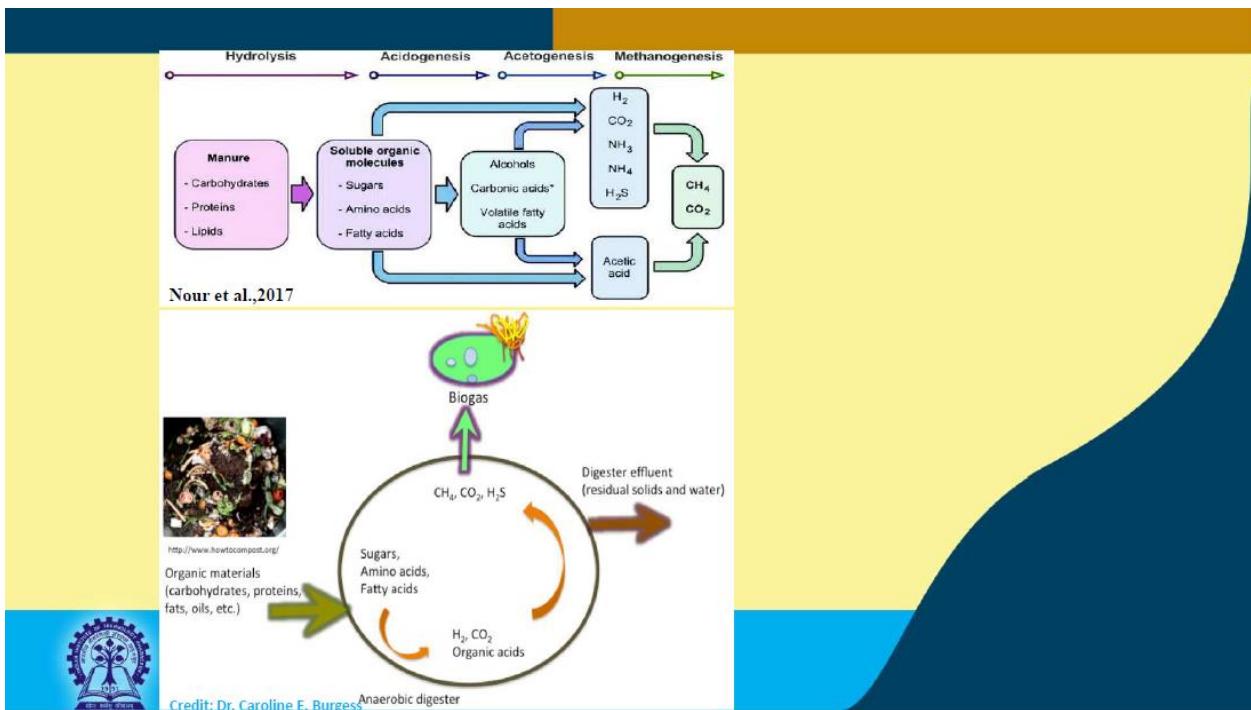
7.

Which of the following is the correct sequence of waste degradation mechanisms in anaerobic digestion?

- a. Hydrolysis – acidogenesis – acetogenesis – methanogenesis
- b. Acidogenesis – acetogenesis – hydrolysis - methanogenesis
- c. Hydrolysis – acetogenesis – acidogenesis - methanogenesis
- d. Hydrolysis – methanogenesis – acetogenesis – acidogenesis

Correct Answer:- a

Detailed Solution:-



8.

Limestone is the \_\_\_\_\_ sink of carbon.

- a. Atmospheric
- b. Hydrospheric
- c. Biospheric
- d. Lithospheric

Correct Answer:- d

Detailed Solution:-

## **Carbon Sinks:**

- Lithosphere – limestone (largest reservoir)
- hydrosphere – ocean (2<sup>nd</sup> largest)
- Atmosphere – in form of CO<sub>2</sub>
- biosphere – wood, plants, dead animals



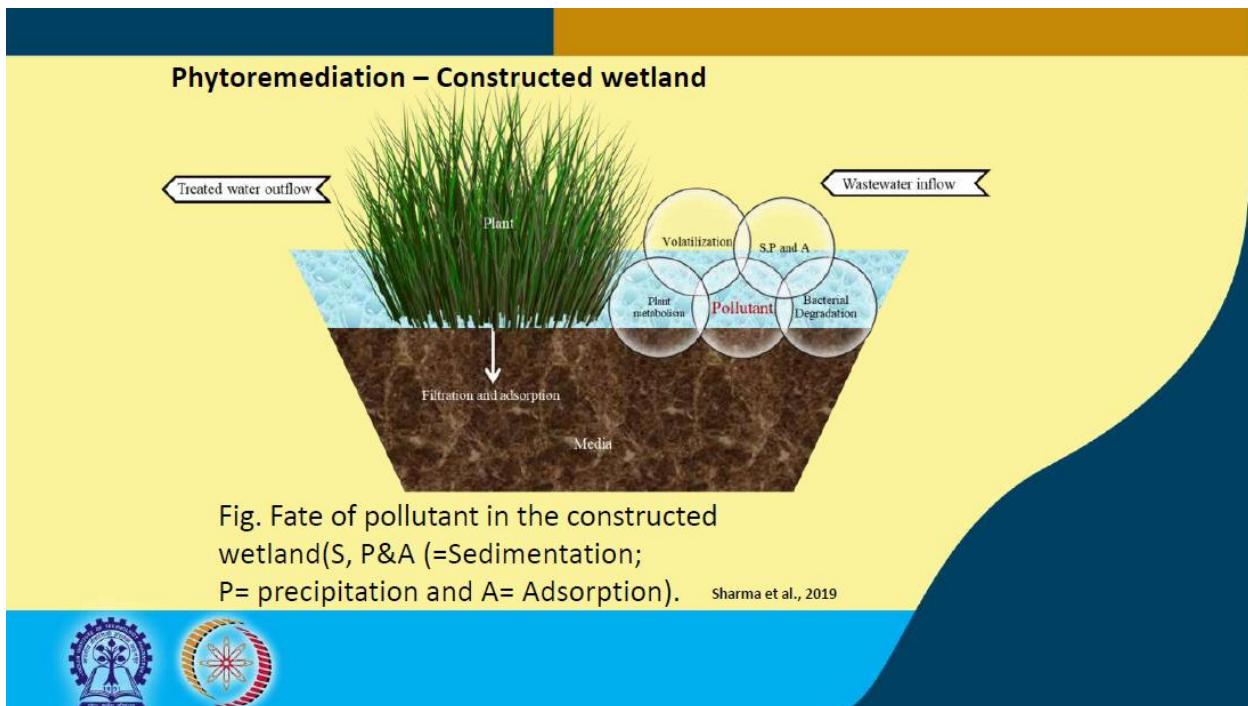
9.

Phytoremediation is the process of removing contaminants using \_\_\_\_\_.

- a. plants
- b. nanoparticles
- c. microorganisms
- d. all of the above

Correct Answer:- a

Detailed Solution:-



10.

Match the followings

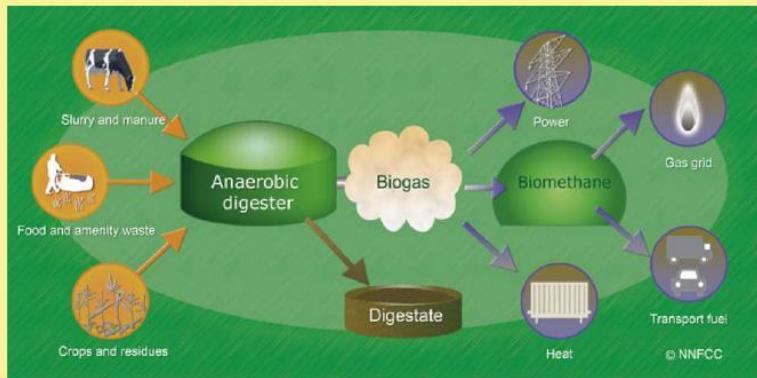
1.	Use of biogas	i)	Reduction in atmospheric release of landfill gas
2.	Benefit of anaerobic digestion	ii)	Amino acid
3.	Conversion of CO <sub>2</sub> , H <sub>2</sub> to CH <sub>4</sub>	iii)	Transport fuel
4.	Building block of protein	iv)	Methanogenesis

- a. 1(i), 2(iii), 3(ii), 4(iv)
- b. 1(iii), 2(i), 3(iv), 4(ii)
- c. 1(iv), 2(ii), 3(iii), 4(i)
- d. 1(ii), 2(i), 3(iv), 4(iii)

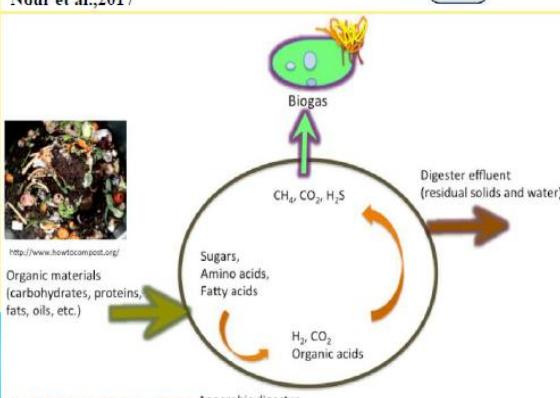
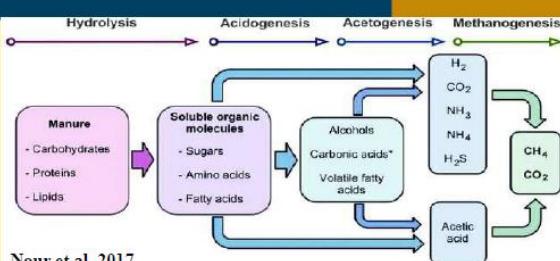
Correct Answer:- b

Detailed Solution:-

# Anaerobic Digestion



<http://www.biogas-info.co.uk/about/>



## **Applications:**

- Waste and wastewater treatment.
- Reduces the emission of landfill gas into the atmosphere.
- Power generation.
- Fertilizer and soil conditioner.
- Cooking gas.
- Vehicle fuel.



Section 2 : Select all the correct answers

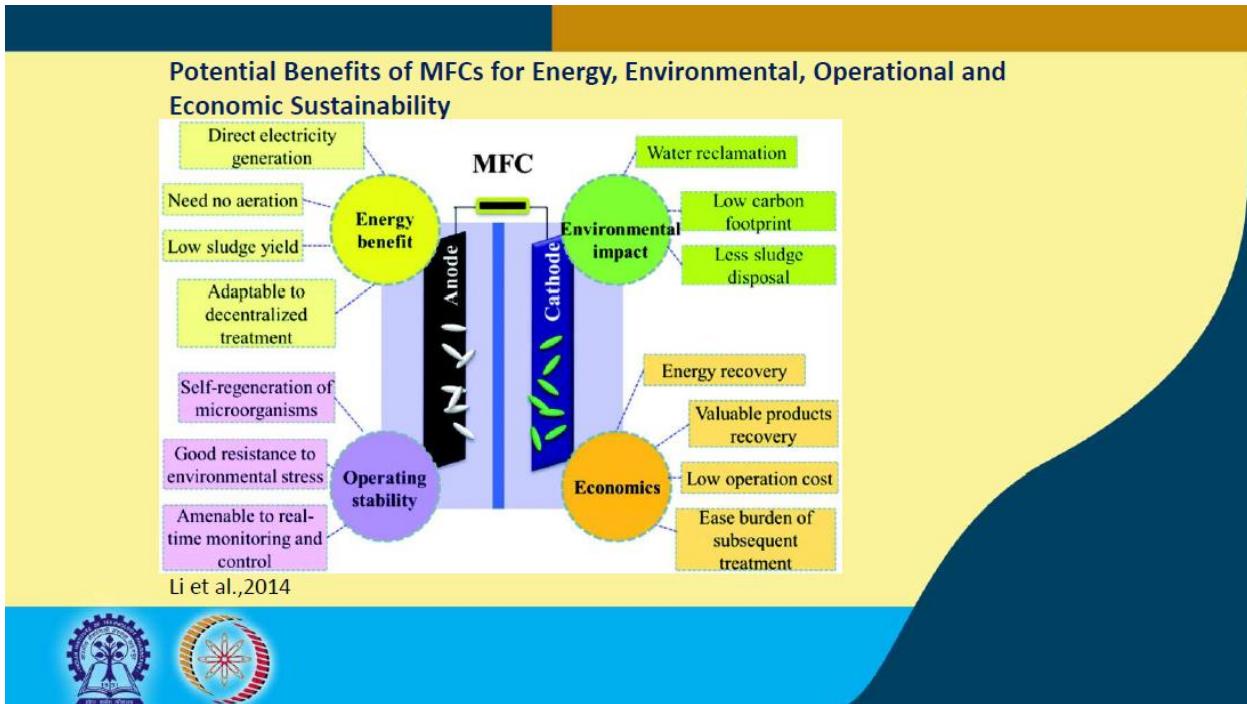
11.

Which of the following options is/are correct related to the microbial fuel cell (MFC)?

- a. MFC stands for methanogenic fuel cell
- b. MFC involves low sludge yield
- c. MFC has a low carbon footprint
- d. MFC needs a continuous air supply

Correct Answer:- b, c

Detailed Solution:-



12.

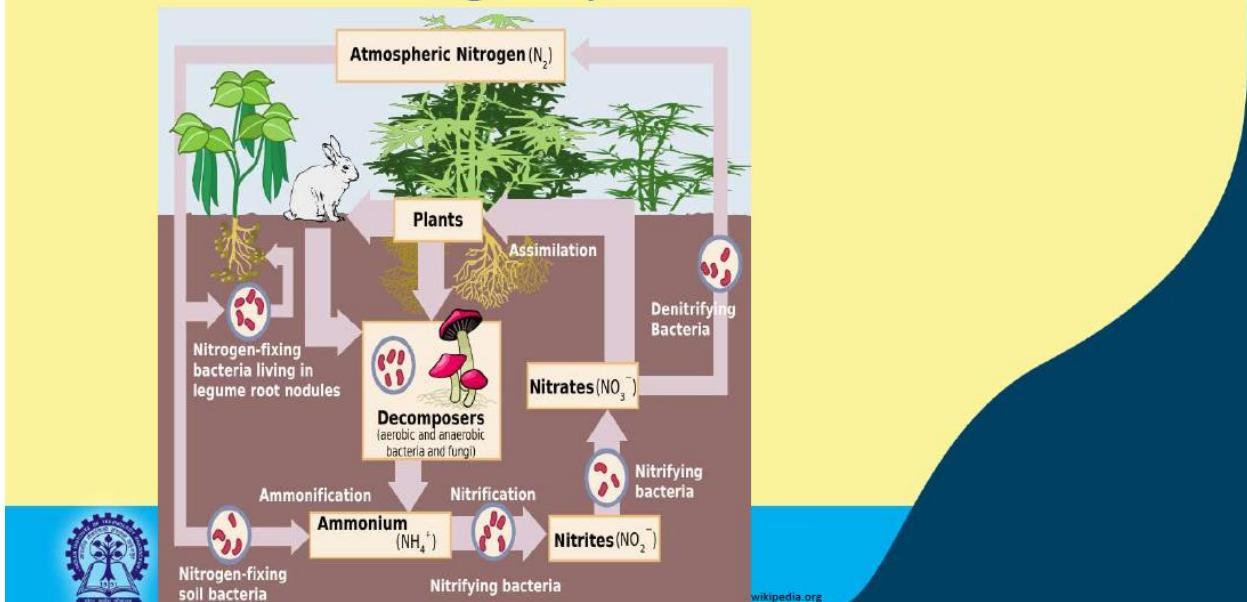
Which of the following statements is/are correct related to the Nitrogen cycle?

- Nitrification is the process of converting ammonium to nitrate
- Nitrifying bacteria helps in converting Nitrogen into ammonium
- Nitrogen assimilation is the process of formation of organic nitrogen compounds from inorganic nitrogen compounds in the environment
- Denitrifying bacteria convert nitrite into nitrate

Correct Answer:- a, c

Detailed Solution:-

# Nitrogen cycle



- 78% of the volume of troposphere
- Most complex cycle
- $N_2$  gas can't be used 'as is' – it must be 'fixed' so that organisms can use it
- $N_2$  gas is modified by "nitrogen-fixing" bacteria in legumes into ammonia ( $NH_3$ ) – NITROGEN FIXATION – aids in production of sugars/starches
- Bacteria turn wastes and detritus into ammonia – AMMONIFICATION – released into atm
- $NH_3$  is converted into nitrite ( $NO_2^-$ ) which is then used to produce nitrate ( $NO_3^-$ ) - NITRIFICATION

13.

Eutrophication can be avoided by which of the following process?

- a. reducing the use of phosphates as builders in detergents
- b. adding phosphate-rich plant materials from affected lakes
- c. aerating lakes by external sources
- d. removing phosphate-rich sediments by dredging

Correct Answer:- a, c, d

Detailed Solution:-



### Measures to reduce artificial eutrophication

- 1. Reducing the use of phosphates as builders in detergents
- 2. Reducing the use of nitrate containing fertilizers
- 3. Using tertiary sewage treatment methods to remove phosphate and nitrate before discharging the effluent into rivers and lakes
- 4. Directing waste water away from lakes to safe treatment & disposal sites
- 5. Aerating lakes and reservoirs to prevent oxygen depletion particularly during algal blooms
- 6. Removing phosphate- rich plant material from affected lakes
- 7. Removing phosphate rich sediments by dredging



14.

Which of the following statements is/are correct concerning the BOD?

- a. BOD of water depends on temperature
- b. BOD applies to any material
- c. BOD of a sample varies with time
- d. High BOD in water leads to high oxygen availability to aquatic animals

Correct Answer:- a, c

Detailed Solution:-

# Oxygen Demand

**Biochemical oxygen demand or BOD** is a chemical procedure for determining the amount of dissolved **oxygen** needed by aerobic **biological** organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.

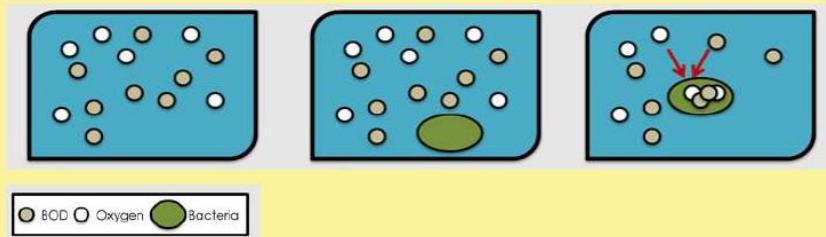
## Aerobic decomposition



## Aerobic decomposition



## Simple BOD concept



In receiving stream, high BOD level can cause depleted oxygen, making it difficult for aquatic animal to survive.



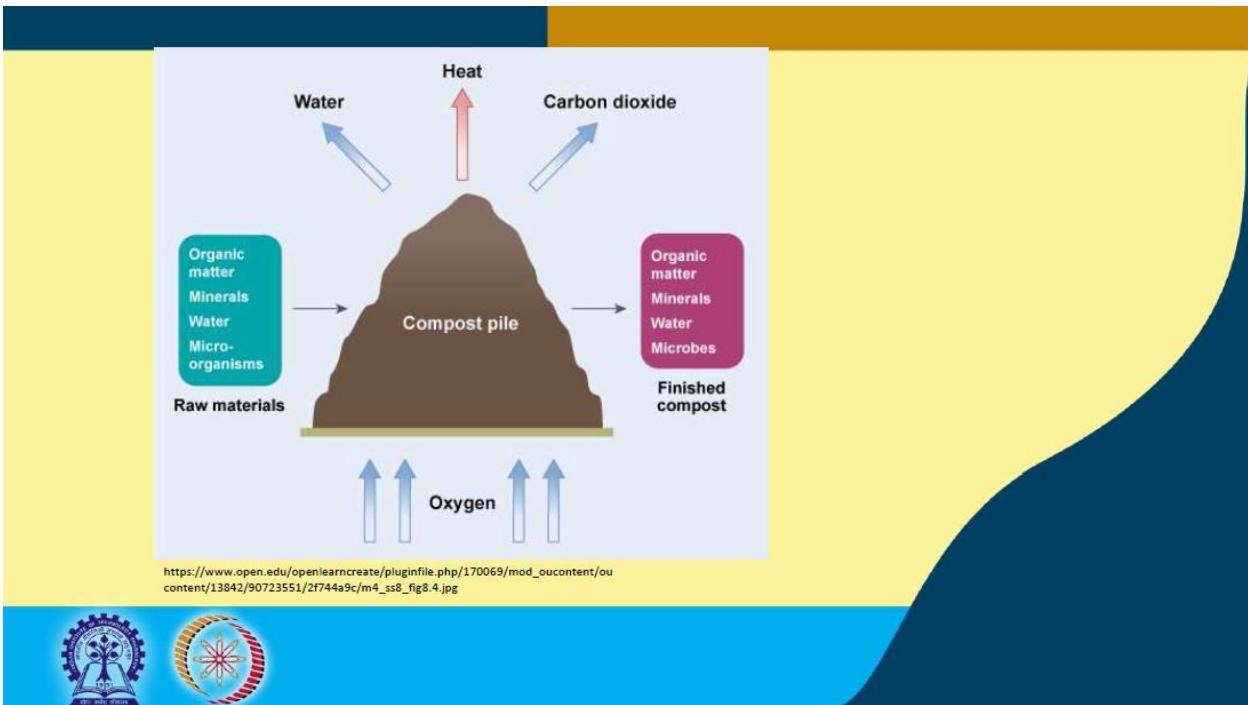
15.

Which of the following statements is/are correct corresponding to the composting process?

- Composting is an anaerobic process
- Composting is the adsorption of organic matter onto microorganisms
- Composting depends on temperature
- Compost contains nutrients for plant growth

Correct Answer:- c, d

## Detailed Solution:-



## Introduction to Environmental Engineering and Science – Fundamentals and Sustainability Concepts

### Assignment- Week 6

1. Which of the following is/are a part of risk management?

- a. Risk identification
- b. Risk control
- c. Risk monitor
- d. All of the above

**Correct Answer:- d**

**Detailed Solution:-**



2.

The term used for the dosage of a non-carcinogenic substance considered safe for humans is known as \_\_\_\_\_.

- a. Applied dose
- b. Absorbed dose
- c. Reference dose
- d. None

**Correct Answer:- c**

**Detailed Solution:-**

### Risk Definitions 1

- Applied dose – The amount of chemical in a medium that is available for uptake
- Absorbed dose – The amount of chemical absorbed into the body [related to the fraction of applied dose that is absorbed; need to consider route of exposure [ingestion, skin, inhalation]]
- Reference dose [RfD] – The dose of a non-carcinogen that is believed safe for humans [usually extrapolated from animal toxicity data]

The diagram shows a cross-section of a human body. On the left, a textured surface is labeled 'Skin Surface'. Below it, a vertical column represents the 'Applied Dose' with four arrows pointing downwards. The next level is the 'Bloodstream', shown as a red vessel. From the bloodstream, an arrow points to a dark red organ labeled 'Target Organ'. Inside the target organ, several small circles represent 'Target Cells'. A final arrow points from the target cells to a box labeled 'Biologically Effective Dose (BED)'. The path from applied dose to delivered dose is labeled 'Absorbed Dose', and the path from delivered dose to target cells is labeled 'Delivered Dose'.

3.

What could be the potential functional unit for Life Cycle Assessment when comparing electric bikes and diesel bikes?

- a. One electric bike
- b. One diesel bike
- c. Energy required for running 10000 km
- d. None of the above

**Correct Answer:- c**

**Detailed Solution:-**

## Function & Functional Unit

### Function

- Service provided by a system
- What it does!

### Functional Unit

- Gives the function a number value
- Allows comparison between products
- Reference point

### Example

Wooden Pencil vs. Mechanical Pencil

- Function = "Writing"
- Functional Unit = "1 meter of writing"



4.

What is the permissible absorbed concentration of Cr(VI) in risk assessment when the RfD value is set at 0.2 mg/L?

- a. 0.2 mg/L
- b. 0.1 mg/L
- c. 0.4 mg/L
- d. 0.3 mg/L

**Correct Answer:- b**

**Detailed Solution:-**

- Hazard index [HI] = Ratio of absorbed dose to the RfD
  - HI < 1 is an "acceptable" situation
  - HI > 1 needs the chemical concentration to be decreased

HI < 1; Absorbed dose/RfD < 1, Absorbed dose < RfD, i.e. 0.1 mg/L (all other options are > RfD)

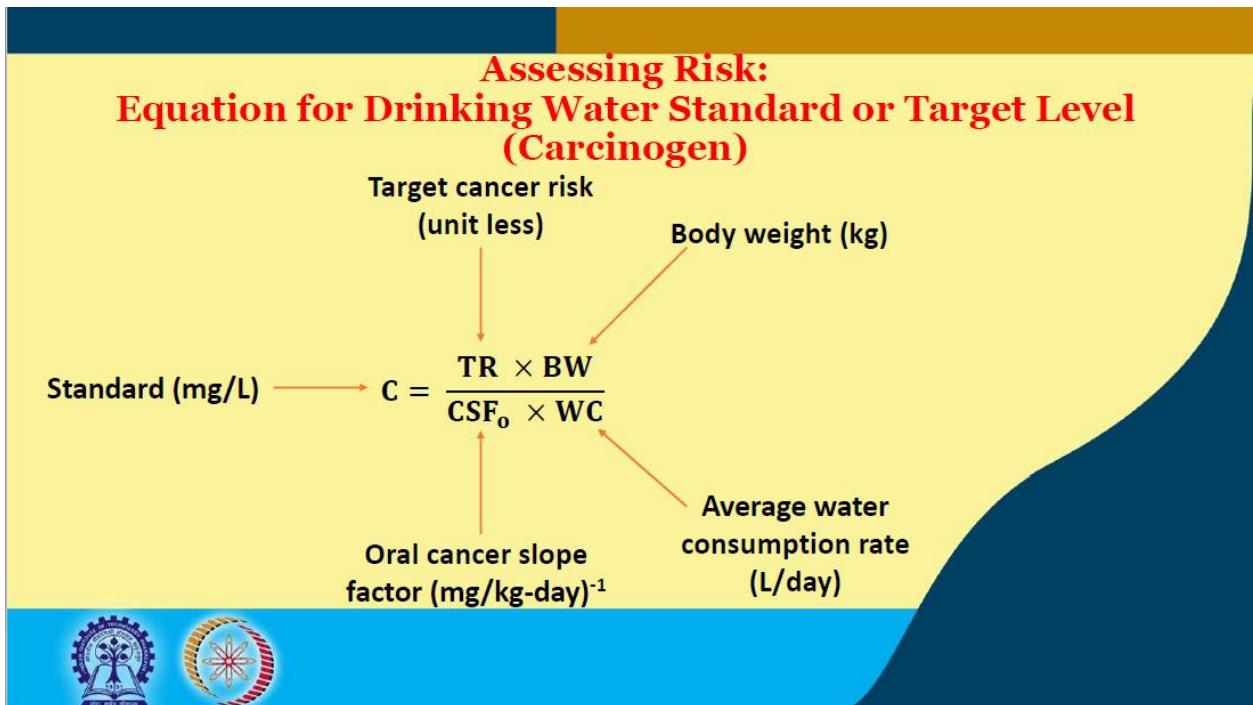
5.

Which of the following is the correct equation for getting drinking water standards for carcinogens?

- a.  $c = \frac{TR \times BW}{CSF_0 \times WC}$
- b.  $c = \frac{TR \times BW}{RFD_0 \times WC}$
- c.  $c = \frac{TR \times BW}{RFD_0 \times IR}$
- d.  $c = \frac{TR \times BW}{CSF_0 \times IR}$

**Correct Answer:- a**

**Detailed Solution:-**



6. What is the correct order of different steps involved in risk assessment?

- a. Hazard identification – risk characterization – dose-response evaluation – exposure assessment
- b. Hazard identification – dose-response evaluation – risk characterization – exposure assessment
- c. Exposure assessment – dose-response evaluation – risk characterization – hazard identification
- d. Hazard identification – dose-response evaluation – exposure assessment – risk characterization

**Correct Answer:- d**

**Detailed Solution:-**



7. Which element of the environment includes the cultural life of people?

- a. Physical environment
- b. Aesthetic environment
- c. Social environment
- d. Economic environment

**Correct Answer:- c**

**Detailed Solution:-**

## Different elements of Environment

- Physical Environment (include Physical, chemical and biological factors)
- Social Environment (social and cultural life of the people)
- Economic Environment (employment and unemployment levels, average income, economic base, etc.)
- Aesthetic Environment (historical, archaeological, architectural objects or sites; scenic areas, views and landscape)



8. EIA is the abbreviation of \_\_\_\_\_.

- a. Ecological Impact Assessment
- b. Environmental Impact Assessment
- c. Ethical Impact Assessment
- d. None

**Correct Answer:- b**

**Detailed Solution:-**

## Why EIA?

In principle, environmental assessment can be undertaken for individual projects such as a dam, motorway, airport or factory and call it as 'Environmental Impact Assessment' (EIA).

Plans, programs and policies and call it as 'Strategic Environmental Assessment' (SEA).

9. Which of the following is the definition of Sustainable development?

- a. Fulfilling the need of the present generation only
- b. Fulfilling the need of future generations by compromising the need of the present generation
- c. Fulfilling the need of the present generation without compromising the ability of future generations to meet their own needs
- d. All of the above

**Correct Answer:- c**

**Detailed Solution:-**

### We can do better

Sustainable development meets the needs of the present **without compromising** the ability of future generations to meet their own needs.

10.

Which one is the correct sequence of phases for the environmental clearance procedure in India?

- a. Screening - scoping – public hearing environment management plan – decision making
- b. Screening – scoping – decision making – public hearing environment management plan
- c. Screening – public hearing environment management plan – scoping – decision making
- d. Public hearing environment management plan – screening – scoping – decision making

**Correct Answer:- a**

**Detailed Solution:-**

## Environmental Clearance Procedure in India

The EIA process in India is made up of the following phases:

- ✓ Screening;
- ✓ Scoping and consideration of alternatives;
- ✓ Baseline data collection impact prediction;
- ✓ Assessment of alternatives, delineation of mitigation measures and environmental impact statement;
- ✓ Public hearing Environment Management Plan;
- ✓ Decision making;
- ✓ Monitoring the clearance conditions.

The Ministry of Environment and Forests (MoEF) has published guidelines for different sectors.



\*\*\*\*\*Select all the correct answers\*\*\*

11.

Which of the following statements is/are correct if the risk associated with any incident is low?

- a. Probability of occurrence – frequent, severity of the incident - critical
- b. Probability of occurrence – occasional, severity of the incident - negligible
- c. Probability of occurrence – improbable, severity of the incident - catastrophic
- d. Probability of occurrence – improbable, severity of the incident - negligible

**Correct Answer:- b, d**

**Detailed Solution:-**

## Risk Assessment

**Risk assessment** provides a qualitative or quantitative estimation of the likelihood of adverse effects that may result from exposure to specific health hazards or from the absence of beneficial influences.

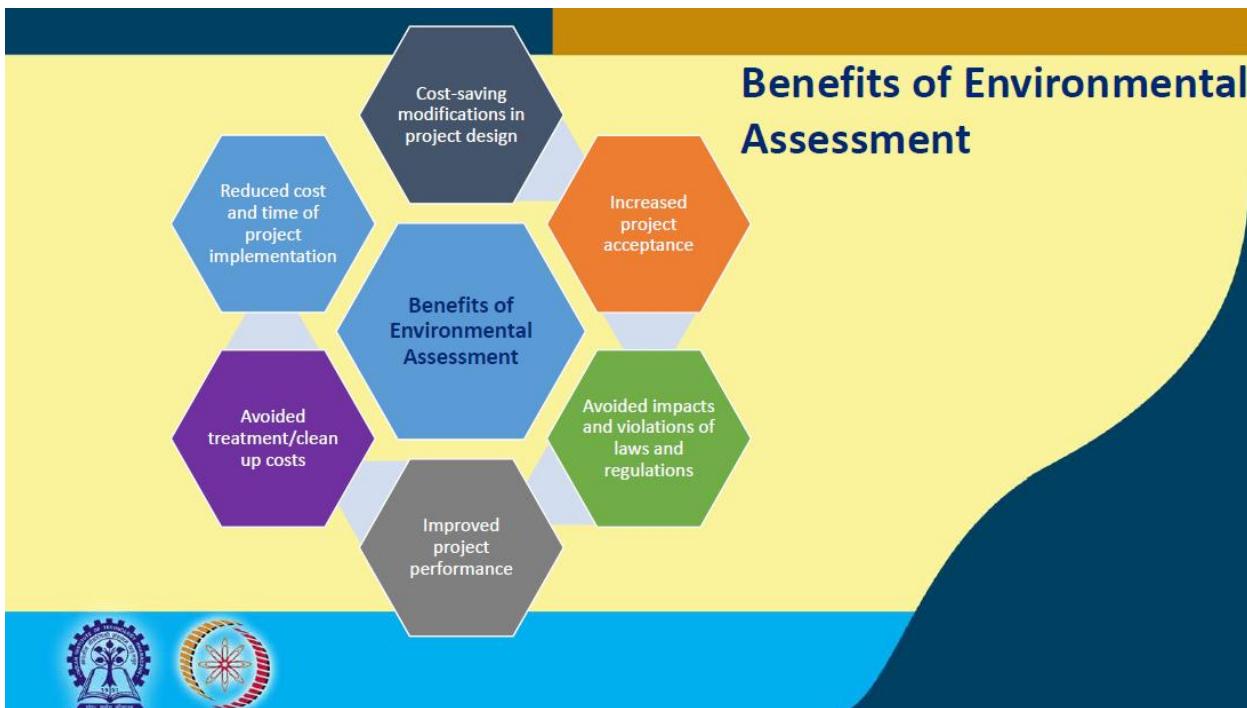
		RISK ASSESSMENT MATRIX			
SEVERITY PROBABILITY \	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)	
Frequent (A)	High	High	Serious	Medium	
Probable (B)	High	High	Serious	Medium	
Occasional (C)	High	Serious	Medium	Low	
Remote (D)	Serious	Medium	Medium	Low	
Improbable (E)	Medium	Medium	Medium	Low	
Eliminated (F)	Eliminated				

12. Which of the following is/are correct for EIA?

- EIA helps in increasing project acceptance
- EIA considers only social impact of any proposed plan prior to decision making
- EIA helps in avoiding additional treatment/clean-up cost
- EIA helps in avoiding violation of laws and regulations

**Correct Answer:- a, c, d**

**Detailed Solution:-**



13. Which of the following is/are the purpose of scoping?

- a. Identify the most important effects to be considered in EIA
- b. Minimize the wastage of time on unnecessary investigations
- c. Identify information necessary for decision making
- d. Utilizing money for all possible investigations

**Correct Answer:- a, b, c**

**Detailed Solution:-**

## Scoping

The scoping process identifies the issues that are likely to be of **most importance** during the EIA and eliminates those that are of little concern. Typically, this process **concludes** with the establishment of Terms of Reference for the preparation of an EIA.

In this way, scoping ensures that EIA studies are **focused on the significant effects** and time and money are not wasted on unnecessary investigations.

**Major issues** and impacts that will be **important in decision-making** on the proposal, and need to be addressed in an EIA



## Purpose of scoping is to identify

- The important issues to be considered in an EIA;
- The appropriate time and space boundaries of the EIA study;
- The information necessary for decision-making; and
- The significant effects and factors to be studied in detail.

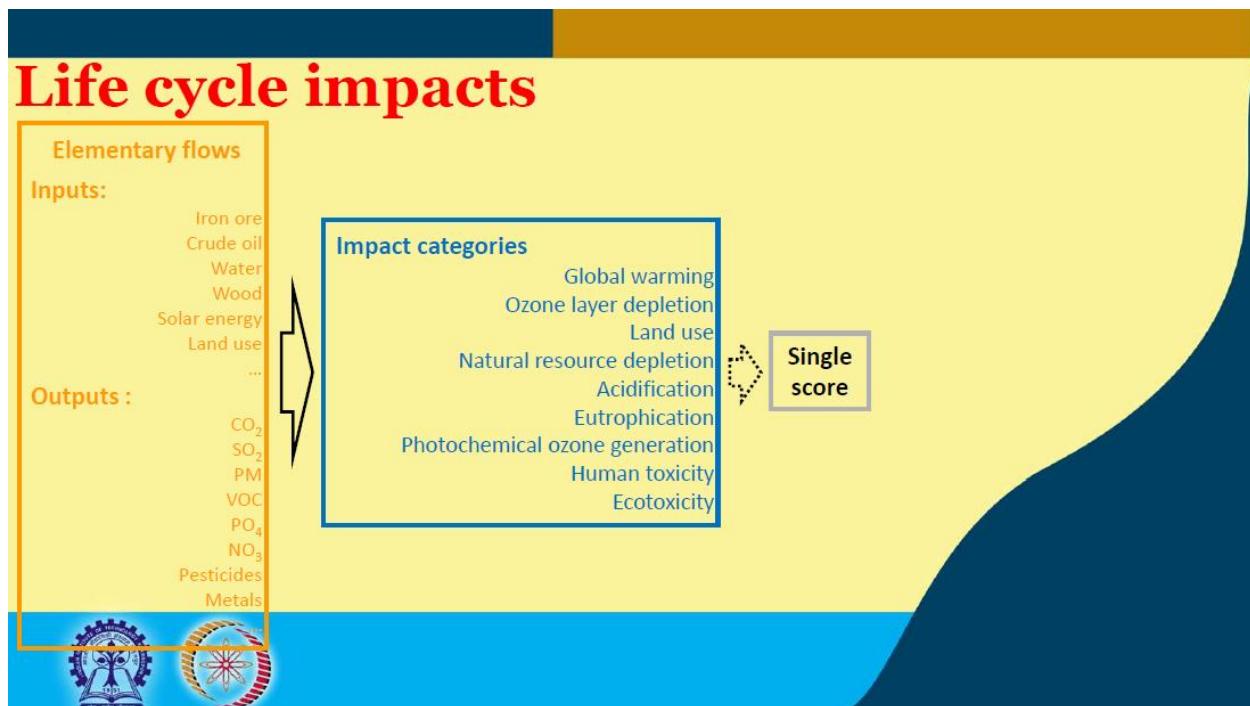


14. Which of the following is/are different impact categories for the LCA study?

- a. Acid rain
- b. Eutrophication
- c. Population
- d. Ozone layer depletion

**Correct Answer:- a, b, d**

**Detailed Solution:-**



15.

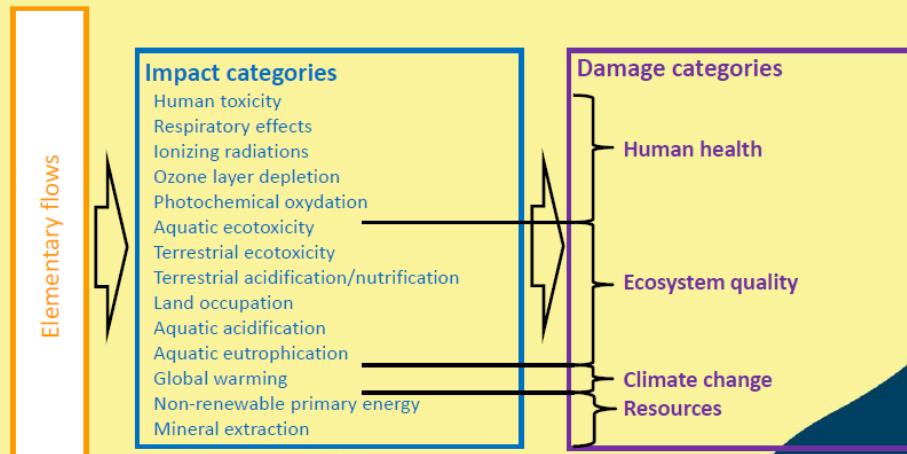
Which of the following is classified under ecosystem damage in the context of a Life Cycle Assessment (LCA) study?

- a. Ionizing radiations
- b. Aquatic ecotoxicity
- c. Mineral extraction
- d. Aquatic eutrophication

**Correct Answer:- b, d**

**Detailed Solution:-**

## IMPACT2002+ = A combined approach



From Joliet et al. (2003) IMPACT2002+





## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

### Assignment- 7

#### TYPE OF QUESTION: MCQ/MSQ

Number of questions: 15

Total Marks  $15 \times 2 = 30$

#### QUESTION 1:

Which form of nitrogen indicates the fully oxidized organic matter in water?

- a. Free ammonia
- b. Organic Nitrogen
- c. Nitrite
- d. Nitrate

Correct Answer: d

Detailed Solution:

#### **Nitrogen content**

The presence of nitrogen in water may occur in one or more of the following reasons:

- 1. Free ammonia:** It indicates very first stage of decomposition of organic matter. It should not exceed 0.15mg/l
- 2. Organic nitrogen:** It indicates the quantity of nitrogen present in water before the decomposition of organic matter has started. It should not exceed 0.3mg/l
- 3. Nitrates:** Not fully oxidized organic matter in water.
- 4. Nitrates:** It indicates fully oxidized organic matter in water (representing old pollution).

#### QUESTION 2:

Name the group of bacteria that can survive with or without free oxygen.

- a. Microaerophiles
- b. Facultative bacteria
- c. Anaerobic bacteria
- d. Aerobic bacteria

Correct Answer: b

Detailed Solution:



**Classification of bacteria based on oxygen requirement:**

**Aerobic bacteria:** Those which require oxygen for their survival.

**Anaerobic bacteria:** Those which flourish in the absence of free oxygen.

**Facultative bacteria:** Those which can survive with or without free oxygen.

### QUESTION 3:

Which instrument is used to measure the odour of water?

- a. pH meter
- b. Conductivity meter
- c. Turbidity meter
- d. Osmoscope

Correct Answer: d

Detailed Solution:

#### **Taste and odour**

Due to dissolved organic matter or inorganic salts, dissolved gases etc.

The **threshold odour number** is the **dilution factor** at which the odour is just detectable.

$$\text{Dilution factor} = \frac{\text{Volume of raw water sample} + \text{Volume of distilled water used for dilution}}{\text{Volume of raw water sample}}$$

Instrument: Osmoscope

Permissible limit: 1 to 3

### QUESTION 4:

100 mL water sample is taken in an empty dry container whose initial weight is 34.563 gm. After oven drying the sample at 103 °C for 24 hours its final weight was measured to be 34.589 gm. Calculate the total solid concentration of water in mg/L.

- a. 100 mg/L
- b. 160 mg/L
- c. 260 mg/L
- d. 200 mg/L

Correct Answer: c

Detailed Solution:

$$\text{Total solids} = \frac{W_2 - W_1}{V} \times 10^6$$

$W_2$ = final weight in gm,

$W_1$ = initial weight in gm,

$V$  = volume of water sample in ml

$$\text{Total solids} = (34.589 - 34.563)/100 * 10^6 = 260 \text{ mg/L}$$

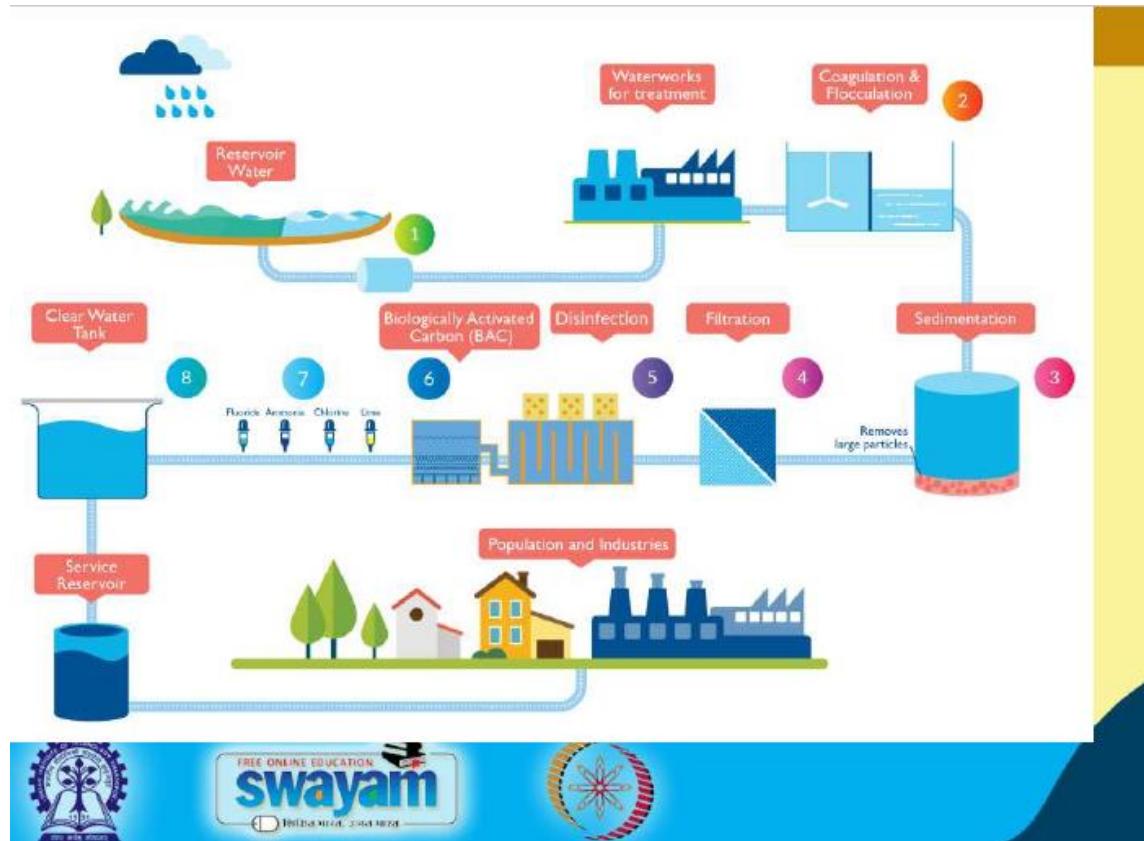
### QUESTION 5:

Which of the following is the correct sequence for the processes in surface water treatment?

- Coagulation & Flocculation--Disinfection--Filtration--Sedimentation
- Coagulation & Flocculation--Sedimentation--Disinfection--Filtration
- Coagulation & Flocculation--Sedimentation--Filtration--Disinfection
- Coagulation & Flocculation--Disinfection--Sedimentation--Filtration

Correct Answer: c

Detailed Solution:



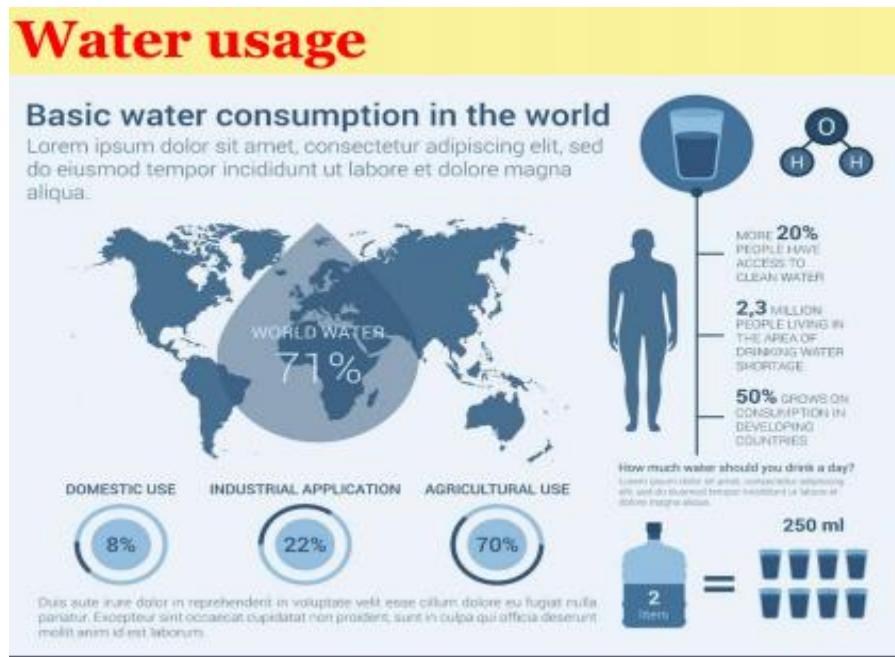
### QUESTION 6:

Which of the following statement(s) is/are true regarding water usage?

- 8% of the water is used for domestic purpose
- 22% of the water is used for industrial applications
- 70% of the water is used for agricultural activities
- All the above

Correct Answer: d

Detailed Solution:



### QUESTION 7:

Which disease can result from the ingestion of water containing higher nitrate concentrations?

- Typhoid
- Cholera
- Methemoglobinemia
- Dysentry

Correct Answer: c

Detailed Solution:



## Nitrogen content

- Nitrites is highly dangerous and therefore the permissible amount of nitrites in water should be nil.
- Ammonia nitrogen + organic nitrogen = kjeldahl nitrogen
- Nitrates in water is not harmful. However the presence of too much of nitrates in water may adversely affect the health of infants causing a disease called **methemoglobinemia** commonly called **blue baby disease**.
- The nitrate concentration in domestic water supplies is limited to 45 mg/l.

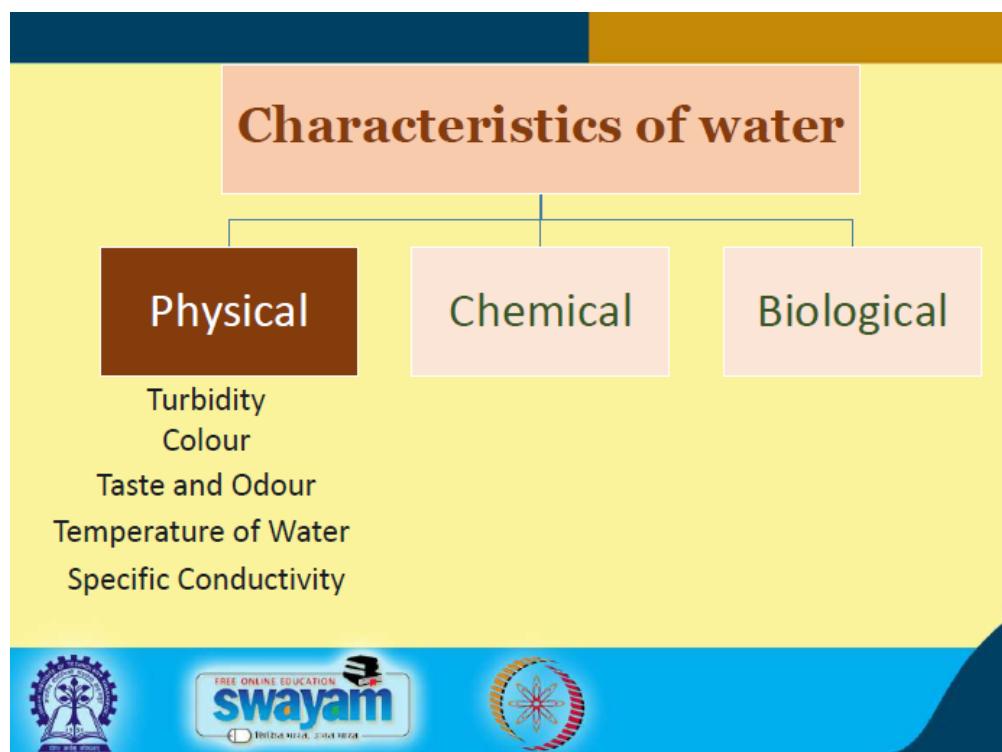
### QUESTION 8:

Identify the physical properties of water from the following.

- Turbidity
- Colour
- Total solids
- Dissolved gas

Correct Answer: a, b

Detailed Solution:



**QUESTION 9:**

Identify the characteristics of safe water from the following.

- a. Contains bacteria
- b. Presence of organic matter
- c. Chemically safe
- d. Aesthetically acceptable

Correct Answer: c,d

Detailed Solution:



**QUESTION 10:**

Calculate the quantity of stormwater runoff if the rainfall intensity is 4 mm/min, and the overall runoff coefficient is 0.6. Given the catchment area is 400 ha?

- a. 1600 m<sup>3</sup>/s
- b. 160 m<sup>3</sup>/s
- c. 2600 m<sup>3</sup>/s
- d. 260 m<sup>3</sup>/s

Correct Answer: b

Detailed Solution:

Quantity of stormwater,  $Q = C.I.A/360$



$$= 0.6 \times 400 \text{ ha} \times 4 \text{ mm/min} * 60 \text{ min/hr} / 360 \\ = 160 \text{ m}^3/\text{s}$$

**QUESTION 11:**

Which population forecasting method is suited for a new industrial town at the beginning of development?

- a. Geometrical increase method
- b. Arithmetic mean method
- c. Graphical method
- d. Incremental increase method

Correct Answer: a

Detailed Solution:

**Geometrical Increase Method**

- In this method the percentage increase in population from decade to decade is assumed to remain constant.
- Geometric mean increase is used to find out the future increment in population.
- Since this method gives higher values and hence should be applied for a new industrial town at the beginning of development for only few decades.

The population at the end of  $n^{th}$  decade 'P<sub>n</sub>' can be estimated as:

$$P_n = P (1 + I_G/100)^n$$

Where,  $I_G$  = geometric mean (%)  
P = Present population  
N = no. of decades

**QUESTION 12:**

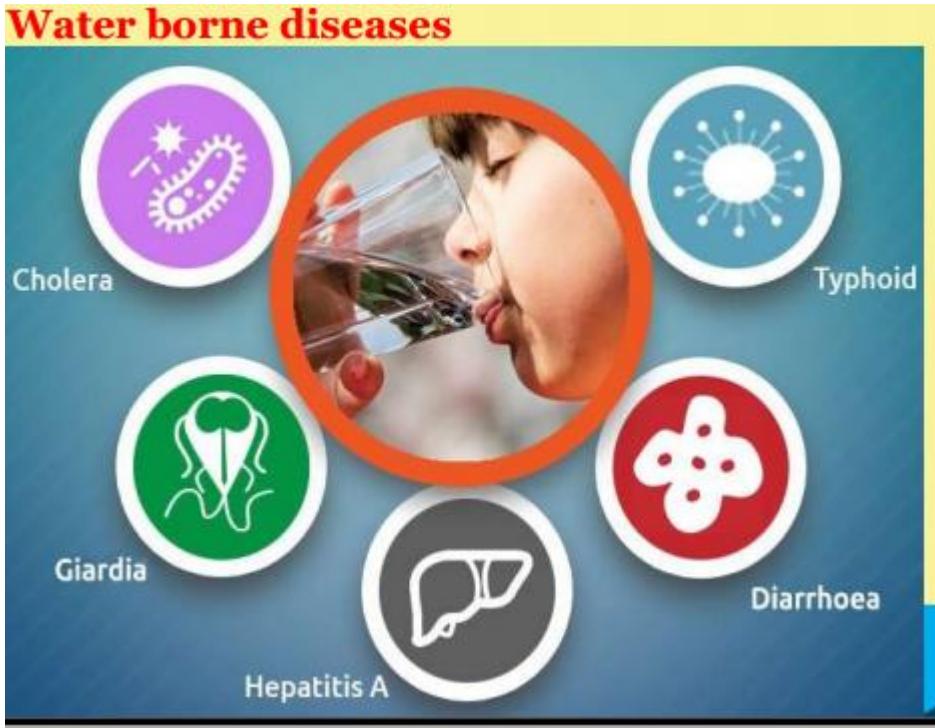
Which of the following is not a water borne disease?

- a. Cholera
- b. Typhoid
- c. Asthma
- d. Hepatitis B

Correct Answer: c

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Detailed Solution:



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**QUESTION 13:**

State whether the following statement is True/False.

"If the oxygen present in water is found to be greater than its saturation level, it indicates presence of organic matter."

- a. True
- b. False

Correct Answer: b

Detailed Solution:



### Dissolved oxygen

Oxygen gas is generally absorbed by water from the atmosphere but it being consumed by unstable organic matter for their oxidation. Hence, if the oxygen present in water is found to be less than its saturation level, it indicates presence of organic matter and consequently making the waters suspicious.



#### QUESTION 14:

Predict the population for the year, 2060 from the following population data using the incremental increase method.

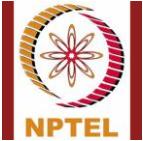
Year	1960	1970	1980	1990	2000	2010
Population	858545	1015672	1201553	1691538	2077820	2585862

- a. 4526845
- b. 6459872
- c. 5629112
- d. 5412356

Correct Answer: c

Detailed Solution:

Year	Population	Increment (X)	Incremental Increase (Y)
1960	858545	-	-
1970	1015672	157127	-
1980	1201553	185881	+28754
1990	1691538	489985	+304104
2000	2077820	386282	-103703



2010	2585862	508042	+121760
	Total	1727317	350915
	Average	345463	87729

population after  $n^{\text{th}}$  decade is  $P_n = P + n.X + \{n(n+1)/2\}.Y$

$$n = 5$$

$$\begin{aligned}P_{2060} &= 2585862 + (345463 \times 5) + \{(5*(5+1)/2)\} \times 87729 \\&= 5629112\end{aligned}$$

#### QUESTION 15:

Identify the formula for calculating the maximum daily water demand.

- a.  $2.5 \times \text{Average daily demand}$
- b.  $2.7 \times \text{Average daily demand}$
- c.  $1.5 \times \text{Average daily demand}$
- d.  $1.8 \times \text{Average daily demand}$

Correct Answer: d

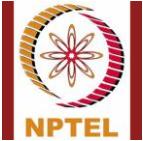
Detailed Solution:

### Variation in water demand

Maximum daily demand =  $1.8 \times \text{Average daily demand}$

Maximum hourly demand =  $1.5 \times 1.8 \times \text{Average daily demand}$   
 $= 2.7 \times \text{Average daily demand}$

\*\*\*\*\*END\*\*\*\*\*



## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

### Assignment- 8

TYPE OF QUESTION: MCQ/MSQ

Number of questions: 15

Total Marks  $15 \times 2 = 30$

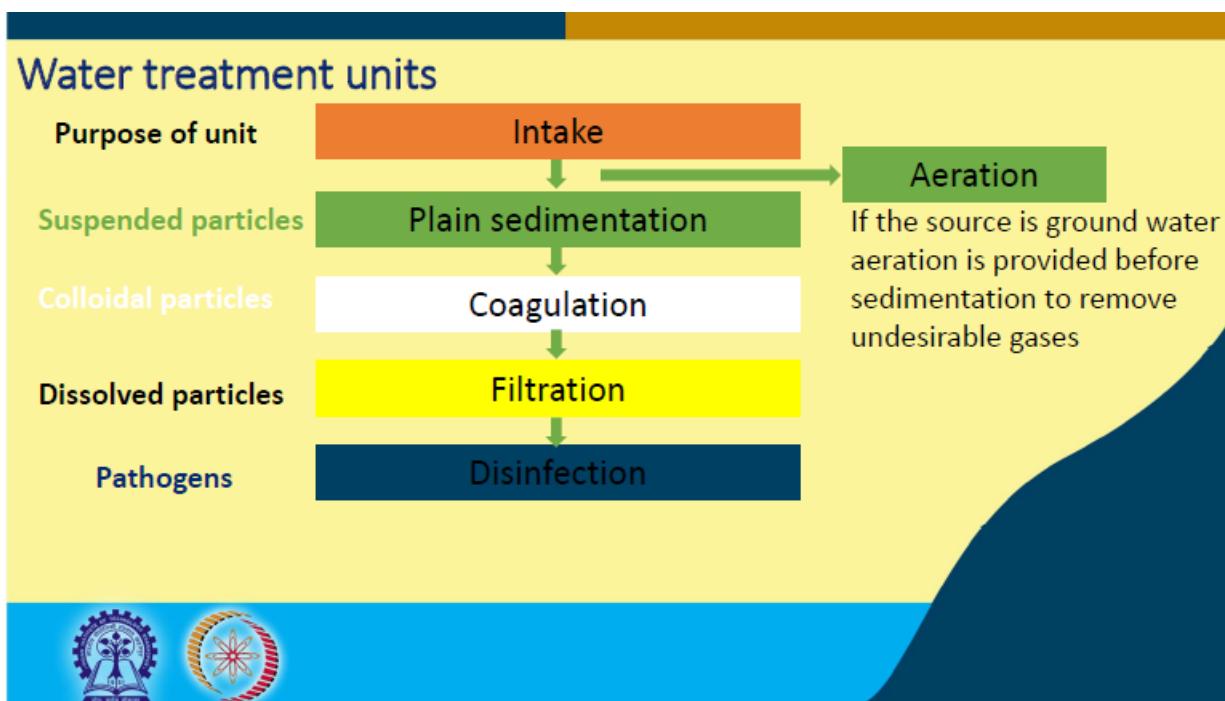
#### QUESTION 1:

Which treatment process is designed for removing pathogens in a water treatment plant?

- a. Plain sedimentation
- b. Coagulation
- c. Filtration
- d. Disinfection

Correct Answer: d

Detailed Solution:



**QUESTION 2:**

Which of the following law establishes the relationship between particle size and its settling velocity?

- a. Pascal's law
- b. Darcy's law
- c. Stoke's law
- d. Hooke's law

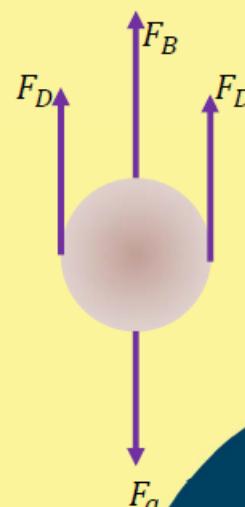
Correct Answer: c

Detailed Solution:

**Plain sedimentation Tank: Theory**

The movement of a particle in a fluid is determined by a balance of the viscous drag forces resisting the particle movement with gravitational or other forces that cause the movement.

A force balance called stokes law is used to determine the relationship between particle size and its settling velocity.






**QUESTION 3:**

Match the following;

- |             |                                 |
|-------------|---------------------------------|
| A. Type I   | i. Flocculent particle settling |
| B. Type II  | ii. Zone settling               |
| C. Type III | iii. Compression settling       |
| D. Type IV  | iv. Discrete particle settling  |
- a. A-iv, B-i, C-ii, D-iii  
 b. A-iv, B-i, C-iii, D-ii  
 c. A-i, B-ii, C-iii, D-iv  
 d. A-iv, B-iii, C-ii, D-i

Correct Answer: a

Detailed Solution:

### Types of Settling

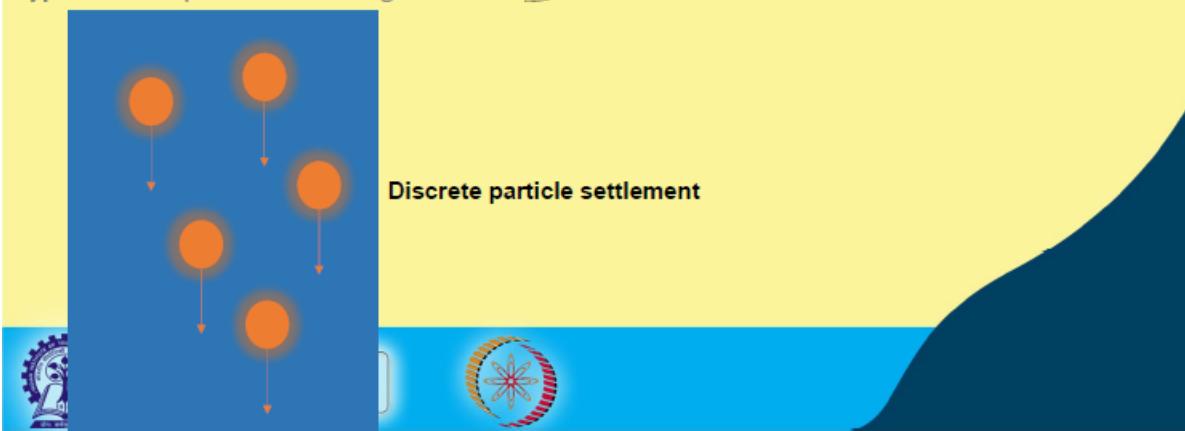
**Type I: Discrete particle settling** - Particles settle individually without interaction with neighboring particles.

**Type II: Flocculent Particle settlement**

**Type III: Hindered or Zone settling**

**Type IV: Compression settling**

*Will be discussed in coming slides*





QUESTION 4:

A sedimentation tank designed to capture 0.015 mm diameter particles with a specific gravity of 2.65. If the sedimentation tank is designed for a surface overflow rate of 30 m<sup>3</sup>/day/m<sup>2</sup>. Find the efficiency of particle removal. Take the kinetic viscosity of water: 0.01 cm<sup>2</sup>/sec.

- a. 64.98 %
- b. 58.27 %
- c. 48.69 %
- d. 38.85 %

Correct Answer: b

Detailed Solution:

$$\begin{aligned}\text{Settling velocity } v_s &= \frac{g(\rho_p - \rho_f)}{18\mu} D_p^2 \\ &= \{[9.81 * (2.65 - 1)] / [18 * 0.01 * 10^{-4}]\} * (0.015 * 10^{-3})^2 \\ &= 2.02 * 10^{-4} \text{ m/s} = 17.48 \text{ m/day}\end{aligned}$$

$$\eta = V_s / V_o \times 100$$

$$\begin{aligned}&= (17.48 / 30) * 100 \\ &= 58.27\%\end{aligned}$$

QUESTION 5:

Which of the following is not a coagulant?

- a. Aluminium sulphate
- b. Ferrous Sulphate
- c. Sodium hydroxide
- d. Sodium sulphate

Correct Answer: c

Detailed Solution:



**QUESTION 6:**

Which of the following is not the characteristic of a slow sand filter?

- a. It will have a long design life
- b. It requires high power and chemical requirements
- c. It is inexpensive and easy to construct
- d. It reduces bacteria, colloids, and organic contaminants

Correct Answer: b

Detailed Solution:



### Advantages of the Slow Sand Filter

- ❖ Long design life
- ❖ Can use local materials and labor
- ❖ Inexpensive and easy to construct
- ❖ Minimal sludge handling problems
- ❖ Close operator supervision is not necessary
- ❖ Viable for the 21<sup>st</sup> century
- ❖ Reduces bacteria, cloudiness, and organic levels
- ❖ Minimal power and chemical requirements



### QUESTION 7:

Find the length and width of the slow sand filter required to handle 3 MLD of water with a filtration rate of 150 lit/hr/m<sup>2</sup>. Assume Length: Width = 1:2.

- a. B=10.6 m, L= 11.2 m
- b. B=15.2, L=30.4
- c. B=20.5, L=41
- d. B=25 m, L=50 m

Correct Answer: c

Detailed Solution:

$$\text{Surface area of slow sand filter} = Q/\text{rate of filtration}$$

$$L \times B = (3 \times 10^6) / (150 \times 24) = 833.33 \text{ m}^2$$

$$L = 2B$$

$$2B^2 = 833.33$$

$$B = 20.5 \text{ m}$$

$$L = 41 \text{ m}$$



### QUESTION 8:

Which of the following is not a disinfection method?

- a. Boiling
- b. Coagulation
- c. Silver or electro-katadyn process
- d. Chlorination

Correct Answer: b

Detailed Solution:

### Disinfection

It is the process of killing pathogenic bacteria.

Methods

Boiling of water

Treatment with excess lime

Ozone

Iodine and bromine pills UV rays

KMnO<sub>4</sub>

Silver or electro-katadyn process

Chlorination



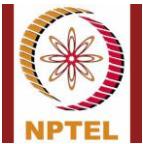
### QUESTION 9:

Identify the correct order of chlorine forms in terms of their disinfecting strength.

- a. ClO<sub>2</sub> > Free chlorines > Chloramines
- b. ClO<sub>2</sub> > Chloramines > Free chlorines
- c. ClO<sub>2</sub> = Free chlorines = Chloramines
- d. Free chlorines > ClO<sub>2</sub> > Chloramines

Correct Answer: a

Detailed Solution:



## Strength of Disinfectants

$O_3 > ClO_2 > \text{Free chlorines} > \text{Chloramines}$

- Little to zero residual for  $O_3$  and  $ClO_2$
- Free chlorine is cheaper than  $O_3$  and  $ClO_2$
- Chloramines offer longer residual and are less reactive
  - Combined chlorine
- What about  $Cl^-$  (chloride) and UV?



### QUESTION 10:

Find  $Cl_2$  demand, if  $Cl_2$  dose of 0.8 mg/L is added to have  $Cl_2$  residual of 0.3 mg/L. Find the dose of bleaching powder required if it contains only 20% of  $Cl_2$ .

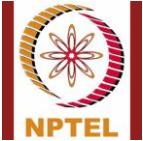
- $Cl_2$  demand=0.4 mg/L, Bleaching powder dosage=2 mg/L
- $Cl_2$  demand=0.2 mg/L, Bleaching powder dosage=3 mg/L
- $Cl_2$  demand=0.4 mg/L, Bleaching powder dosage=5 mg/L
- $Cl_2$  demand=0.5 mg/L, Bleaching powder dosage=4 mg/L

Correct Answer: d

Detailed Solution:

$$Cl_2 \text{ demand} = Cl_2 \text{ dose} - Cl_2 \text{ residual}$$
$$= 0.8 - 0.3 = 0.5 \text{ mg/L}$$

$$Bleaching \text{ powder} = Cl_2 \text{ dose} / \% \text{ of } Cl_2 \text{ in bleaching powder}$$
$$= 0.8 / (20/100) = 4 \text{ mg/L}$$



**QUESTION 11:**

The design flow rate for a water supply system is;

- a. Equal to maximum day demand plus fire demand
- b. Equal to maximum hourly rate
- c. Maximum of Maximum day demand plus fire demand and Maximum hourly rate
- d. Minimum of Maximum day demand plus fire demand and Maximum hourly rate

Correct Answer: c

Detailed Solution:

## Hydraulic Design

- The design flowrate is based on the maximum of the following two rates:
  - Maximum day demand plus fire demand
  - Maximum hourly rate
- Analysis of distribution system:
  - Distribution system have series of pipes of different diameters. In order to simplify the analysis, skeletonizing is used.
    - Skeletonizing is the replacement of a series of pipes of varying diameters with one equivalent pipe or replacing a system of pipes with one equivalent pipe.



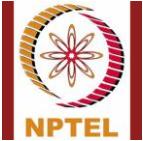
**QUESTION 12:**

Which of the following is not a desired property of disinfectants?

- a. Should not provide any residual
- b. Must be non-toxic and palatable
- c. Must be dispensable and storables
- d. Destroy pathogens within a reasonable time and in various temperatures

Correct Answer: a

Detailed Solution:



## Disinfection

### Desired properties of disinfectants

1. Destroy pathogens within a reasonable time and in various temperatures
2. Must meet possible fluctuations in water quality
3. Must be non-toxic and palatable
4. Must be dispensable and storable
5. Must be able to easily measure concentration in water
6. Must provide residual
7. Cheaper



#### QUESTION 13:

State whether the following statements are True/False.

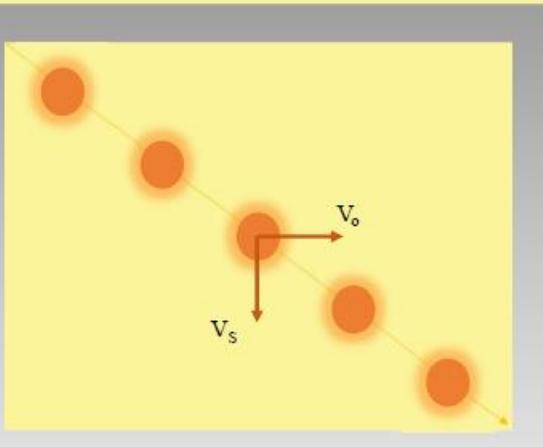
“The suspended particles tend to escape from the settling basin if the settling velocity exceeds the overflow rate.”

- a. True
- b. False

Correct Answer: b

Detailed Solution:

## Settling Basin



$V_s < V_o$       Particle escape

$V_s > V_o$       Particle captured

$V_s = V_o$       Particle captured



### QUESTION 14:

A 4 number of rapid sand filters treat 20 MLD of water with rate of filtration 4000 lit/hr/m<sup>2</sup>. Find the volume of filtered water required to backwash each filter, if backwashing rate is 5 times rate of filtration. Duration of backwash is 15 mins and it is carried out once in every 24 hours.

- a. 260.4 m<sup>3</sup>
- b. 153.9 m<sup>3</sup>
- c. 364.8 m<sup>3</sup>
- d. 230.1 m<sup>3</sup>

Correct Answer: a

Detailed Solution:

$$\text{Surface area of rapid sand filter} = Q/\text{rate of filtration}$$

$$L \times B = (20 \times 10^6) / (4000 \times 24) = 208.33 \text{ m}^2$$

$$\text{Area of each filter} = 208.33 / 4 = 52.08 \text{ m}^2$$

$$\text{Volume of water used in backwash} = \text{ROB} \times \text{DOB} \times \text{Area of each filter}$$

$$= 5 \times 4000 \times (15/60) \times 52.08 = 260400 \text{ litres}$$



**QUESTION 15:**

Which of the following statement(s) is/are true regarding rapid sand filters?

- A filter that operates continuously typically requires backwashing on a monthly basis.
- Large quantities of backwash water and sludge generated from filtration can be directly discharged to the environment.
- Because of the higher filtration rates, the area requirement of a rapid filtration plant is about 20% of that required for the slow sand filters.
- Operating a rapid sand filter requires trained personnel.

Correct Answer: c,d

Detailed Solution:

### Rapid Sand Filter

#### Technical description

Rapid sand filtration is a technique common in developed countries for treating large quantities of drinking water.

It is a relatively sophisticated process usually requiring power-operated pumps for backwashing or cleaning the filter bed, and flow control of the filter outlet.

A continuously operating filter will usually require backwashing about every two days when raw water of relatively low turbidity is used.





## Rapid Sand Filter

### Technical description

Pretreatment of the raw water, using chemical flocculation agents in combination with setting tanks, is common where turbidity is high.

Relatively large quantities of filter backwash water, as well as sludge from the settling process, may be generated and require some form of treatment before discharge to the environment. Because of the higher filtration rates, the area requirement of a rapid filtration plant is about 20% of that required for the slow sand filters.



## Rapid Sand Filter

### Operation and Maintenance

Operation of a rapid sand filter consists of regular backwashing. The period between backwashes depends on the quality of the water being filtered. The purpose of backwashing is to remove the suspended material that has been deposited in the filter bed during the filtration cycle. Periodic repacking of the filter bed may be required at infrequent intervals to ensure efficient operation.

### Level of Involvement

Operating a rapid sand filter requires trained personnel.

\*\*\*\*\*END\*\*\*\*\*



## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

Assignment- 9

TYPE OF QUESTION: MCQ/MSQ

**Number of questions: 15**

**Total Marks 15 x 2 = 30**

### **QUESTION 1:**

Which of the following is an anaerobic biological unit in wastewater treatment?

- a. Trickling filter
- b. Activated sludge process
- c. Imhoff tank
- d. Oxidation pond

**Correct Answer: c**

**Detailed Solution:**

### **Treatment processes are classified as :**

(ii) **Primary Treatment** : Removal of large suspended organic solids.

Sedimentation tank : To remove suspended solids

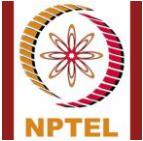
(iii) **Secondary Treatment** : The effluent from sedimentation tank should be stabilized aerobically or anaerobically to get clearer effluents

#### **Aerobic biological units**

- a) Filters : Trickling Filters
- b) Aeration tanks : Activated sludge process
- c) Oxidation ponds

#### **Anaerobic biological units**

- a) Septic tank
- b) Imhoff tank
- c) Sludge digestion tank



### **QUESTION 2:**

Identify the incorrect statement regarding oxygen demand from the following;

- Biochemical oxygen demand is the quantity of oxygen utilized by a mixed population of microorganisms to biologically degrade the organic matter in the wastewater under anaerobic conditions.
- Biochemical oxygen demand is the quantity of oxygen utilized by a mixed population of microorganisms to biologically degrade the organic matter in the wastewater under aerobic condition
- Chemical oxygen demand is the amount of oxygen consumed during chemical oxidation with potassium permanganate or potassium dichromate in an acid solution.
- Theoretical oxygen demand is the oxygen demand that can be worked out theoretically

**Correct Answer: a**

**Detailed Solution:**

**Chemical Oxygen Demand (COD):** It is chemical oxidation with potassium permanganate or potassium dichromate in an acid solution.

**Theoretical oxygen Demand:** It is the oxygen demand that can be worked out theoretically.

**What is Biochemical Oxygen Demand (BOD)?**

**Definition**

The quantity of oxygen utilised by a mixed population of micro-organisms to biologically degrade the organic matter in the wastewater under aerobic condition

### **QUESTION 3:**

Which preliminary treatment unit is designed to remove oils or greases from wastewater?

- Screening
- Equalization tank
- Detritus tank
- Skimming tank

**Correct Answer: d**

**Detailed Solution:**



## Treatment processes are classified as :

- (i) Preliminary treatment
- (ii) Primary treatment
- (iii) Secondary or biological treatment
- (iv) Tertiary treatment

### (I) Preliminary Treatment:

Separating floating materials, heavy inorganic solids.

Processes used :

- (a) Screening : Floating matter removal
- (b) Grit chambers or detritus tanks : To remove grit or sand
- (c) Skimming tanks : To remove oils or greases



### **QUESTION 4:**

In a BOD test, the initial DO of the 3 % diluted sample is 9 mg/l, and its final DO after 5 days of incubation at 20 °C is 3 mg/l. Find the 5-day BOD of the sewage sample.

- a. 100 mg/L
- b. 150 mg/L
- c. 200 mg/L
- d. 250 mg/L

**Correct Answer: c**

### **Detailed Solution:**

$$y_5^{20^\circ\text{C}} = \{[\text{DO}]_{\text{initial}} - [\text{DO}]_{\text{final}}\} \times \text{Dilution factor}$$
$$= (9-3) * (100/3) = 200 \text{ mg/L}$$

### **QUESTION 5:**

Which of the following statements is not true for a Separate sewerage system?

- a. Sewerage being small, difficulty in cleaning them
- b. Frequent choking problem
- c. System proves costly as it involves two sets of sewers
- d. Sewage load on treatment unit is high



**Correct Answer: d**

**Detailed Solution:**

## Systems of Sewerage

### SEPARATE SYSTEM OF SEWERAGE

In this system two sets of sewers are laid. The sanitary sewage is carried through sanitary sewers while the storm sewage is carried through storm sewers. The sewage is carried to the treatment plant and storm water is disposed of to the river.

#### **Advantages:**

- 1) Size of the sewers are small
- 2) Sewage load on treatment unit is less
- 3) Rivers are not polluted
- 4) Storm water can be discharged to rivers without treatment.



## Systems of Sewerage

### SEPARATE SYSTEM OF SEWERAGE

#### **Disadvantage**

- 1) Sewerage being small, difficulty in cleaning them
- 2) Frequent choking problem will be their
- 3) System proves costly as it involves two sets of sewers





### **QUESTION 6:**

State whether the following statement is True/False.

“If  $BOD_5 / COD$  varies between 0.63 and 0.68, then the wastewater can be considered to be fully biodegradable.”

- a. True
- b. False

**Correct Answer: a**

**Detailed Solution:**

#### **BOD/COD ratio:**

1. If  $BOD_u / COD$  lies between 0.92 and 1, then the waste water can be considered to be fully biodegradable.
2. If  $BOD_5 / COD$  vary between 0.63 and 0.68 then the waste water can be considered to be fully biodegradable wastes.

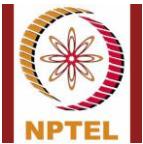
### **QUESTION 7:**

Match the following:

- |                          |                              |
|--------------------------|------------------------------|
| A. Preliminary treatment | i. Chlorination              |
| B. Primary treatment     | ii. Activated sludge process |
| C. Secondary treatment   | iii. Screening               |
| D. Tertiary treatment    | iv. Sedimentation tank       |
- a. A-iii, B-iv, C-ii, D-i  
b. A-iii, B-iv, C-i, D-ii  
c. A-i, B-iv, C-ii, D-iii  
d. A-ii, B-iv, C-iii, D-i

**Correct Answer: a**

**Detailed Solution:**



## Treatment processes are classified as :

- (i) Preliminary treatment
- (ii) Primary treatment
- (iii) Secondary or biological treatment
- (iv) Tertiary treatment

### (I) Preliminary Treatment:

Separating floating materials, heavy inorganic solids.

Processes used :

- (a) Screening : Floating matter removal
- (b) Grit chambers or detritus tanks : To remove grit or sand
- (c) Skimming tanks : To remove oils or greases



## Treatment processes are classified as :

(ii) Primary Treatment : Removal of large suspended organic solids.

Sedimentation tank : To remove suspended solids

(iii) Secondary Treatment : The effluent from sedimentation tank should be stabilized aerobically or anaerobically to get clearer effluents

Aerobic biological units

- a) Filters : Trickling Filters
- b) Aeration tanks : Activated sludge process
- c) Oxidation ponds

Anaerobic biological units

- a) Septic tank
- b) Imhoff tank
- c) Sludge digestion tank

## Treatment processes are classified as :

(iv) Final or Tertiary treatment: To kill pathogenic bacteria chlorination of sewage.

### **QUESTION 8:**

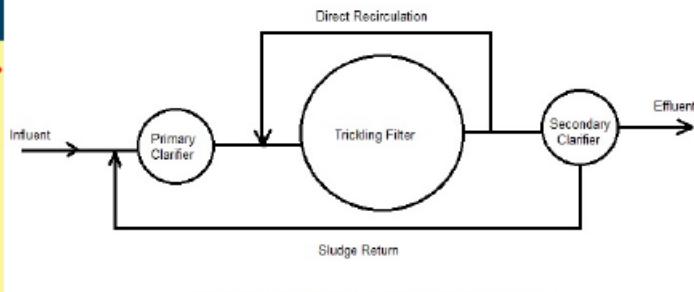
Recirculation in trickling filter helps in;

- Seeding the sewage with bacteria and accelerating the biological oxidation process
- Reducing odours and fly nuisance
- Providing sufficient aeration
- Both a & b

**Correct Answer: d**

**Detailed Solution:**

#### **Single stage trickling filter**



#### **Single Stage Re-circulation Process :**

Recirculation helps in seeding the sewage with bacteria and accelerating biological oxidation process. Recirculation also helps in reducing odours, fly nuisance.

Source:  
<https://www.engineeringexcelpreadsheets.com/2014/04/trickling-filter-design-calculations-spreadsheet/>

### **QUESTION 9:**

What is the BOD<sub>5</sub> of industrial sewage if the Population equivalent of that wastewater is 5000 persons?

- 200 kg/day
- 400 kg/day
- 600 kg/day
- 800 kg/day

**Correct Answer: b**

**Detailed Solution:**

Population Equivalent = BOD<sub>5</sub> of industrial sewage per day / BOD<sub>5</sub> of domestic sewage per person per day

5000 = BOD<sub>5</sub> of industrial sewage per day/ (0.08 kg/day/person)

BOD<sub>5</sub> of industrial sewage per day = 5000\*0.08 = 400 kg/day



### **QUESTION 10:**

Identify the correct order for the arrangement of solids in their increasing size.

- a. Dissolved solids < Suspended solids < Colloidal solids
- b. Dissolved solids < Colloidal solids < Suspended solids
- c. Colloidal solids < Dissolved solids < Suspended solids
- d. Colloidal solids < Suspended solids < Dissolved solids

**Correct Answer: b**

**Detailed Solution:**

**Chemical characteristics:**

Total solids  
↳ Suspended → size upto  $1\mu\text{m}$   
↳ Colloidal →  $1\ \mu\text{m}$  to  $10^{-3}\ \mu\text{m}$   
↳ Dissolved →  $< 10^{-3}\ \mu\text{m}$

### **QUESTION 11:**

Identify the wrong statement regarding the grit chamber from the following.

- a. Grit chambers are provided to reduce maintenance cost in high-speed centrifuges, which needs almost all grit particles to be removed.
- b. Grit chambers are designed to separate out the grit, gravel, sand, egg, shells etc. of size 2 mm or larger.
- c. It is a settling tank with lesser detention time of 1 min and flow velocity of 0.2 to 0.3 m/sec.
- d. Low flow velocity has to be maintained inside a grit chamber for efficient settling of grit particles.

**Correct Answer: d**

**Detailed Solution:**



## Wastewater Grit chamber

Grit chambers are used to remove grit particles present in the wastewater.

Their functions are:

- To protect the mechanical equipment used in the wastewater treatment plant from abrasion.
- To prevent heavy deposits in pipelines and channels
- To reduce the frequency of digester cleaning.
- To reduce maintenance cost in high speed centrifuges which needs almost all grit particles to be removed.



## Wastewater Grit chamber

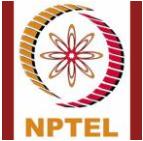
- Grit chambers are used to remove grit present in the wastewater.
- To separate out the grit, gravel, sand, egg, shells etc. of size 2 mm or larger.  
It is a settling tank with lesser detention time of 1 min and flow velocity : 0.2 to 0.3 m/sec.
- The flow velocity should neither be far low as not to cause settling of lighter organic matter nor should it be so high as not to cause the settlement of the entire silt and grit present.

### **QUESTION 12:**

Find the diameter of the standard trickling filter if the influent BOD is 250 mg/L and the desired effluent BOD is 25 mg/L, to handle 3 MLD of waste water flow. Assume depth = 3m.

- a. 46 m
- b. 86 m
- c. 71 m
- d. 40 m

**Correct Answer: c**



**Detailed Solution:**

$$\eta = \frac{y_i - y_e}{y_i} \times 100 = \frac{100}{1 + 0.0044 \sqrt{\frac{Qy_i}{V}}}$$

$$\eta = [(250-25)/250]*100 = \frac{100}{1 + 0.0044 \sqrt{\frac{3*250}{V}}}$$

$$V = 1.176 \text{ ha.m}$$

$$V = 1.176 * 10^4 \text{ m}^3$$

$$\text{Surface area of TF} = \frac{\pi}{4} d^2 = \frac{\text{Volume}}{\text{depth}} = \frac{1.176 * 10^4}{3}$$

$$\text{Diameter (d)} = 70.64 \text{ m}$$

**QUESTION 13:**

Which of the following is a chemical characteristic of wastewater?

- a. Dissolved oxygen
- b. Turbidity
- c. Colour
- d. Odour

**Correct Answer: a**

**Detailed Solution:**

**Physical characteristics:**

- |              |                |
|--------------|----------------|
| 1. Turbidity | 2. Colour      |
| 3. Odour     | 4. Temperature |

**QUESTION 14:**

Identify the correct statement regarding Trickling filter from the following.

- a. Tricling filters are used to remove inorganic particles from wastewater
- b. The Trickling filter is an anaerobic treatment system that utilizes microorganisms attached to a medium to remove organic matter from wastewater.
- c. In these systems, the microorganisms are sustained in a liquid, known as suspended-growth processes.
- d. Trickling filter follows attached-growth processes

**Correct Answer: d**



**Detailed Solution:**

## Trickling filter

- Trickling filters are used to remove organic matter from wastewater.
- The Trickling filter is an aerobic treatment system that utilizes microorganisms attached to a medium to remove organic matter from wastewater.
- This type of system is common to a number of technologies such as rotating biological contactors and packed bed reactors (biotowers).
- These systems are known as attached-growth processes.
- In contrast, systems in which microorganisms are sustained in a liquid are known as suspended-growth processes.

**QUESTION 15:**

Which is the structure designed for maintaining a constant flow velocity in grit chambers?

- a. Spiral aerator
- b. Equalization basin
- c. Parshall flume
- d. Screens

**Correct Answer: c**

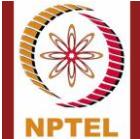
**Detailed Solution:**

## Grit chamber: Proportional weir

With variation in sewage flow received at treatment plant it is important that velocity of the wastewater in the grit chamber should be maintained nearly constant.

Otherwise, when flow is lower deposition of not only inorganic solids but also organic solids will occur in grit chamber due to lowering of velocity; whereas, with higher flow than average, when the velocity will exceed the critical velocity scoring of already deposited grit particle will occur leading to failure of performance. Hence for proper functioning, the velocity should not be allowed to change in spite of the change in flow in the grit chamber. This can be achieved by provision of proportional weir or Parshall flume.

\*\*\*\*\*END\*\*\*\*\*



## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

### Assignment- 10

TYPE OF QUESTION: MCQ/MSQ

**Number of questions: 15**

**Total Marks 15 x 2 = 30**

#### **QUESTION 1:**

Which methodology is used to assess the environmental impact associated with all stages of a product's life cycle?

- a. Material flow analysis
- b. Life cycle assessment
- c. Sensitivity analysis
- d. Risk assessment

**Correct Answer: b**

**Detailed Solution:**

**Present Day**

A big component of waste management is the 3Rs

- . Reduce – at the source
  - . To make something smaller or use less.
  - . Through education and enforcement.
- . Reuse – “re-use” materials in their original form instead of throwing away
  - . Use travel mugs; have a yard sale; donate old clothes, .....

Life-cycle Assessment has been suggested as a way to help solve waste problems

- . Assess the environmental impact associated with all stages of a product's life cycle from “cradle-to-grave ”
- . Helps avoid a narrow outlook on environmental concern.
- . Part of RCRA in the US.

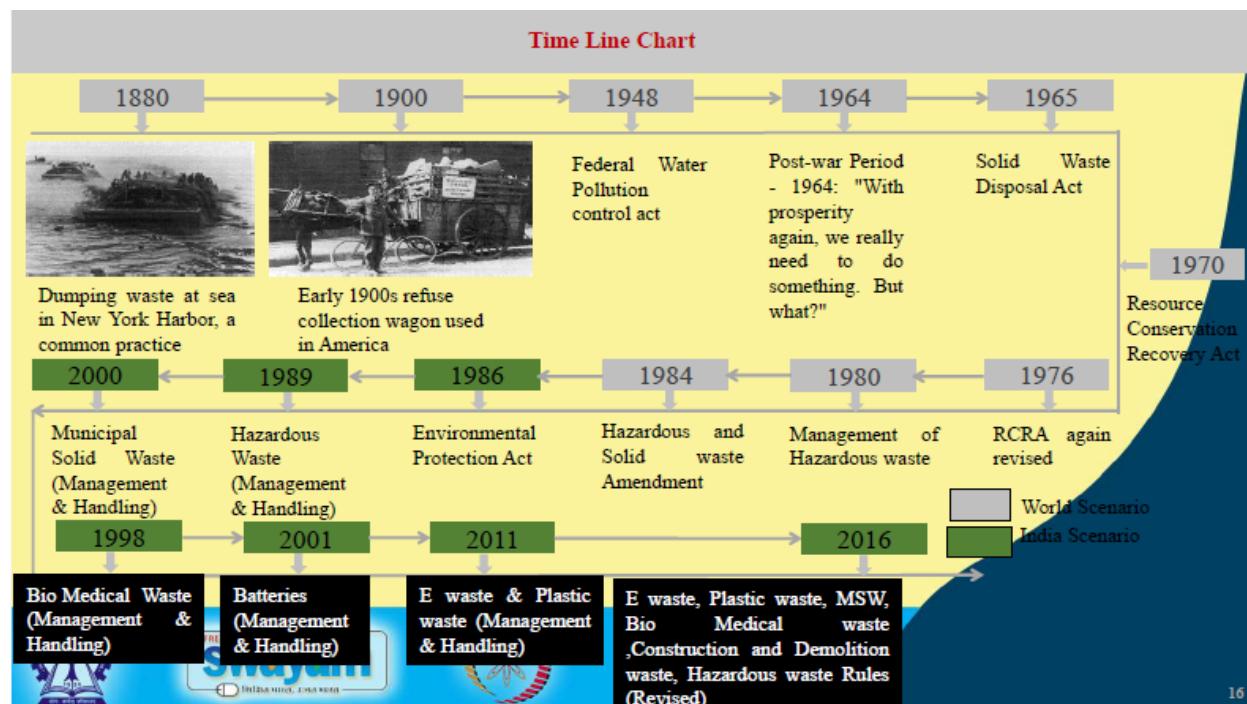
#### **QUESTION 2:**

Match the following;

- |  |           |
|--|-----------|
| A. Solid Waste Disposal Act                  | i. 1970   |
| B. Resource Conservation Recovery Act        | ii. 1986  |
| C. Environmental Protection Act              | iii. 1965 |
| D. Bio-Medical Waste (Management & Handling) | iv. 1998  |
| a. A-i, B-ii, C-iii, D-iv                    |           |
| b. A-iv, B-iii, C-ii, D-i                    |           |
| c. A-iii, B-i, C-ii, D-iv                    |           |
| d. A-iii, B-ii, C-i, D-iv                    |           |

**Correct Answer: c**

**Detailed Solution:**



### **QUESTION 3:**

Which is the correct order of waste management strategies from the most favored to least favored option?

- Reduce – Reuse – Recycle – Energy recovery – Disposal
- Reuse – Reduce – Recycle – Energy recovery – Disposal
- Reduce – Reuse – Energy recovery – Disposal – Recycle
- Energy recovery – Disposal – Reduce – Reuse – Recycle

**Correct Answer: a**

**Detailed Solution:**



#### **QUESTION 4:**

Identify the correct statement(s) regarding landfills from the following;

- a. They are the de-facto choice for waste management and they cause lots of problems for the environment.
- b. Leachate production can be a problem for groundwater.
- c. Methane production causes odour problems around the landfill.
- d. All the above

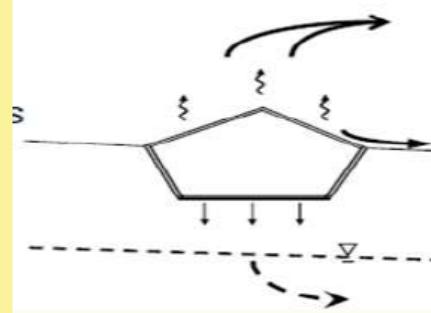
**Correct Answer: d**

**Detailed Solution:**

## Landfills

Landfills are the de-facto choice for waste management and they cause lots of problems for the environment

- . Land usage, air, surface water, ground water, pests(rats, seagulls), noise....
- . Leachate production can be a problem for groundwater
- . Residual contaminants in the waste leach out and leak out of the landfill
- . Highly toxic (- 100 times stronger than sewage) and very odorous
- . Can lead to groundwater contamination (downgradient of the landfill)
- . Methane production can be a problem of air
- . Causes odour problems around the landfill
- . 25 times more powerful than other greenhouse gas
- . Can be beneficial as a renewable energy source
- . Litter is unsightly during landfill operations
- . The area around an active landfill has to deal with lots of debris that is blown around



## QUESTION 5:

The dried solid samples ( whose moisture content is found out ), when ignited at 575 °C for 5 h in a muffle furnace, give \_\_\_\_\_.

- Total solids
- Volatile matter
- Fixed carbon content
- Ash content

**Correct Answer: d**

**Detailed Solution:**



### Properties of solid waste

**Moisture content :** It is weight of the water expressed as the percentage of water in wet or dry weight. To obtain wet weight entire sample is weighed. Then, it is dried in oven at 105°C and dry weight is measured.

Formula :  $(W_w - W_d)/W_d$

W<sub>w</sub> = Wet weight

W<sub>d</sub> = Dry weight

**Ash content:** The dried solid samples ( whose moisture content is found out ) is then ignited at 575 °C for 5 h in a muffle furnace to determine percentage ash (ASTM-E1755).

**Volatile matter:** The volatile matter of dried solid samples is measured by firing at 950 °C for 7 min (ASTM-E872).

The ash, moisture and volatile matter contents were subtracted from 100% to determine the **fixed carbon content** of the samples.



### **QUESTION 6:**

How can the net calorific value of a waste sample be determined?

- a. Gas chromatography
- b. Bomb calorimeter
- c. Dulong formula
- d. Both b & c

**Correct Answer: d**

**Detailed Solution:**

**Net caloric value:** It is defined as the heat produced by unit quantity of waste at constant volume and at constant pressure. It is measured using bomb calorimeter or using formula (using elemental value, Ex: Dulong formula).

### **QUESTION 7:**

Typical solid waste generation in India varies between \_\_\_\_\_.

- a. 0.5-0.9 kg/p/day
- b. 0.3-0.6 kg/p/day
- c. 1.5-1.8 kg/p/day
- d. 0.1-0.2 kg/p/day

**Correct Answer: b**



### Detailed Solution:

#### Typical MSW generation

Small towns 100g/p/day

Medium towns 300-400g/p/day    In general varies between 0.3-0.6 kg/p/day

Large towns 500g/p/day

### **QUESTION 8:**

Identify the advantages of municipal solid waste recycling from the following;

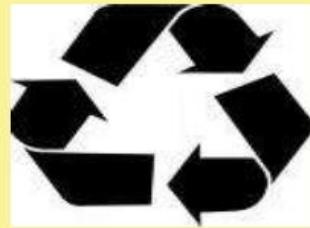
- Require stable market
- Save precious resources
- Poorly managed sites can result in Superfund sites
- Improve the efficiency of incinerators and composting facilities

**Correct Answer: b & d**

### Detailed Solution:

#### Recycling

- Returning raw material to market
- Pros:
  - Save precious resources
  - Lessens need for mining of virgin materials
  - Lowers environmental impact of mining/processing
  - Stretch landfill capacity
  - Improve efficiency of incinerators and composting facilities





## Recycling

Cons:

- Poorly managed sites can result in Superfund sites
  - Waste oil recycling, newspaper de-inking, solvent and metal recycling
  - Can result in contamination of soil, groundwater, air
- Require stable market
- Only works if it is convenient
  - Curbside pick-up
  - Drop off centers
  - Mail back programs



### **QUESTION 9:**

The liquid formed from the degradation of organic fraction of municipal solid waste in the landfill is termed as \_\_\_\_\_.

- a. Leachate
- b. Hydrolysate
- c. Digestate
- d. Condensate

**Correct Answer: a**

**Detailed Solution:**



### Leachate

- Leachate is the liquid (or wastewater) that forms when water (rainfall, groundwater) travels through solid waste
- Leachate can migrate into underlying groundwater, resulting in contamination
- Leachate can contain many different chemicals, depending on what is in the solid waste



### **QUESTION 10:**

Which among the following factors affects the solid waste composition of a region?

- a. Geographic location
- b. Collection frequency
- c. Public attitude
- d. All the above

**Correct Answer: d**

**Detailed Solution:**



## Factors causing variation

- Geographic location
- Seasons
- Collection frequency
- Population diversity
- Extent of salvaging and recycling
- Public attitude
- Legislation



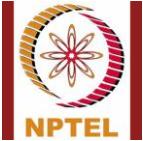
### **QUESTION 11:**

Which of the following gases is not typically found in the composition of landfill gas?

- a. Methane
- b. Carbon dioxide
- c. Hydrogen
- d. Hydrogen sulfide

**Correct Answer: c**

**Detailed Solution:**



### Landfill Gas Contains

- Methane
- Carbon Dioxide
- Water Vapor
- Hydrogen Sulfide
- NMOC (non methane organic compounds)
- heavy metals??



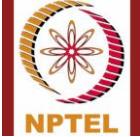
### **QUESTION 12:**

What is the optimal range of C:N ratio for composting?

- a. 10:1 to 15:1
- b. 15:1 to 20:1
- c. 20:1 to 25:1
- d. 25:1 to 30:1

**Correct Answer: c**

**Detailed Solution:**



### Nutrients

- the most critical environmental factor for composting is the relative proportion of carbon and nitrogen (the C:N ratio)
- the optimal range is between 20:1 and 25:1
  - composting time increases with the C:N ratio above 40:1
- individual components of organic matter have different C:N ratios:
  - digested sludge has a low ratio (15:1)
  - yard waste has a high ratio (40:1 – 80:1)
  - newspaper has a very high ratio (175:1 – 800:1)
- to achieve an optimal ratio, organic waste is blended together
- for example, we might add:
  - newsprint – which is high in carbon and low in nitrogen, and
  - yard waste – which is high in nitrogen
  - and, supplement with manure (15:1) or sludge (15:1) if needed



### **QUESTION 13:**

State whether the following statement is True/False.

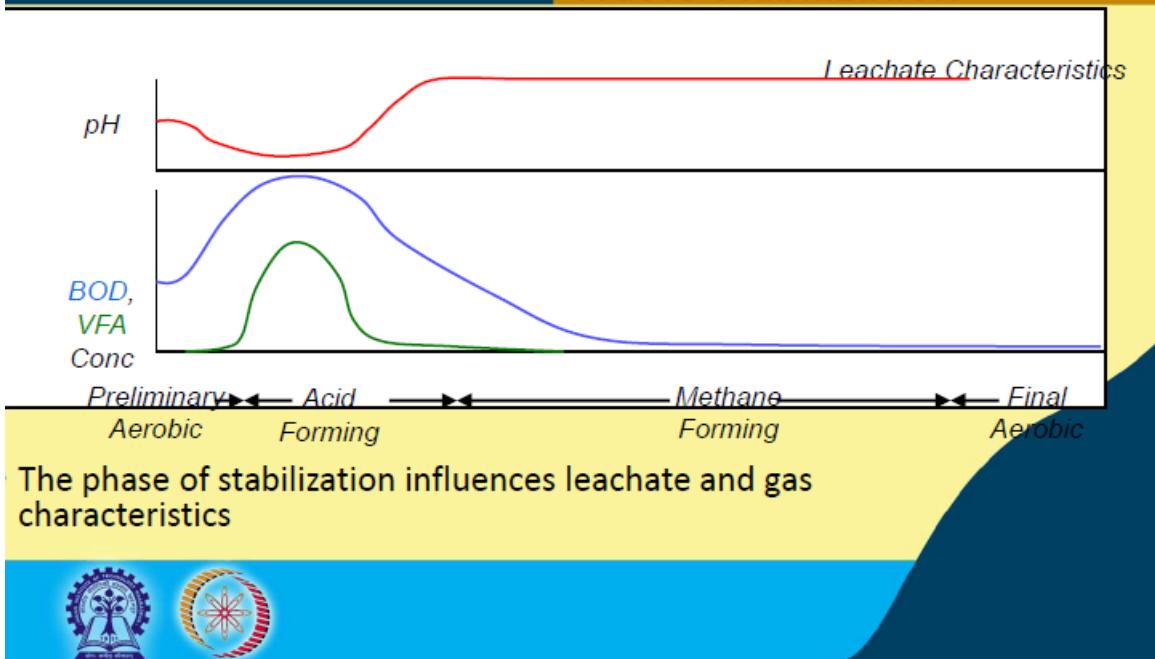
‘During the acid-forming phase of waste in landfills, the production of volatile fatty acids (VFAs) results in low pH conditions.’

- True
- False

**Correct Answer: a**

**Detailed Solution:**

## Waste Stabilization



### **QUESTION 14:**

Identify the correct order for the stabilization of landfill waste from the following.

- Preliminary aerobic phase – Acid forming phase – Methane forming phase – Final aerobic phase
- Preliminary anaerobic phase – Acid forming phase – Methane forming phase – Final anaerobic phase
- Preliminary aerobic phase – Methane forming phase – Acid forming phase – Final aerobic phase
- Preliminary anaerobic phase – Methane forming phase – Acid forming phase – Final anaerobic phase

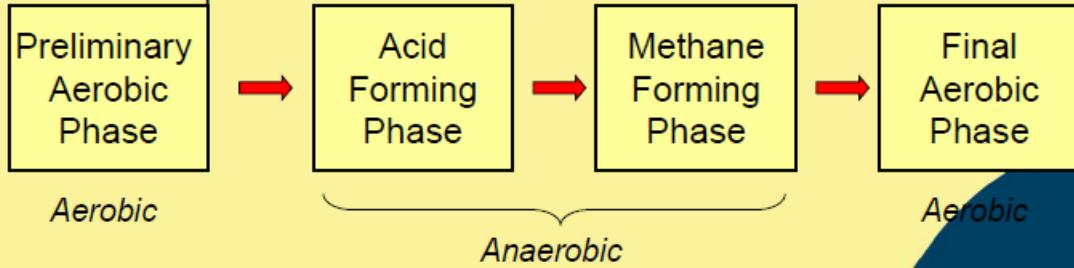
**Correct Answer: a**

**Detailed Solution:**

### Waste Stabilization

- **Phases of Landfill Stabilization**

- Previous investigators have described different phases of landfill stabilization
- Simplified version:



### **QUESTION 15:**

What materials can be used to make the liner of a sanitary landfill?

- Compacted clay
- Sand
- Composite of compacted clay and geomembrane
- None of the above

**Correct Answer: a, c**

**Detailed Solution:**



### Typical Regulatory Requirements

- Liners -- Low permeability barrier layers
  - Compacted soil (clay)
  - Geomembranes (plastic)
  - Composites of both
- Liner keep leachate from migrating out of the landfill
- Leachate must be collected and removed



\*\*\*\*\*END\*\*\*\*\*



## Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

### Assignment- 11

TYPE OF QUESTION: MCQ/MSQ

**Number of questions: 15**

**Total Marks 15 x 2 = 30**

#### **QUESTION 1:**

Which among the following is a secondary air pollutant?

- a. Smoke
- b. Smog
- c. Dust
- d. Ash

**Correct Answer: b**

**Detailed Solution:**

**Types of pollutants**

- On the basis of the form in which they persist

**Primary Pollutants:** These are the substance which are directly emitted from the source and will remain in that form. Examples: smoke, fumes, ash, dust, nitric acid and sulphur dioxide.

**Secondary Pollutants:** The substance which are formed by chemical reaction between the primary pollutants and constituent of the environment. Example: smog, ozone Sulphur trioxide, nitrogen dioxide.



#### **QUESTION 2:**

What is the possible ozone ( $O_3$ ) generation source from the following?

- a. Fuel combustion
- b. Emissions from unpaved roads



- c. Volcanoes
- d. Chemical reaction between VOCs and nitrogen oxides ( $\text{NO}_x$ ) in presence of sunlight.

**Correct Answer: d**

**Detailed Solution:**

Sources, Health Effects, and Other Information Associated with Criteria Air Pollutants (adapted from EPA, 2012a).			
Ozone ( $\text{O}_3$ )	Only criteria pollutant that has no direct sources. This secondary pollutants is typically formed by chemical reaction of VOCs and nitrogen oxides ( $\text{NO}_x$ ) in the presence of sunlight.	Decreases lung function and causes respiratory symptoms, such as coughing and shortness of breath.  Aggravates asthma and other lung diseases leading to increased medication use, hospital admissions, emergency room visits, and premature mortality.	Can damage sensitive plants, reducing crop yields and forest productivity.  Reduces visibility, causing haze in the atmosphere.

### **QUESTION 3:**

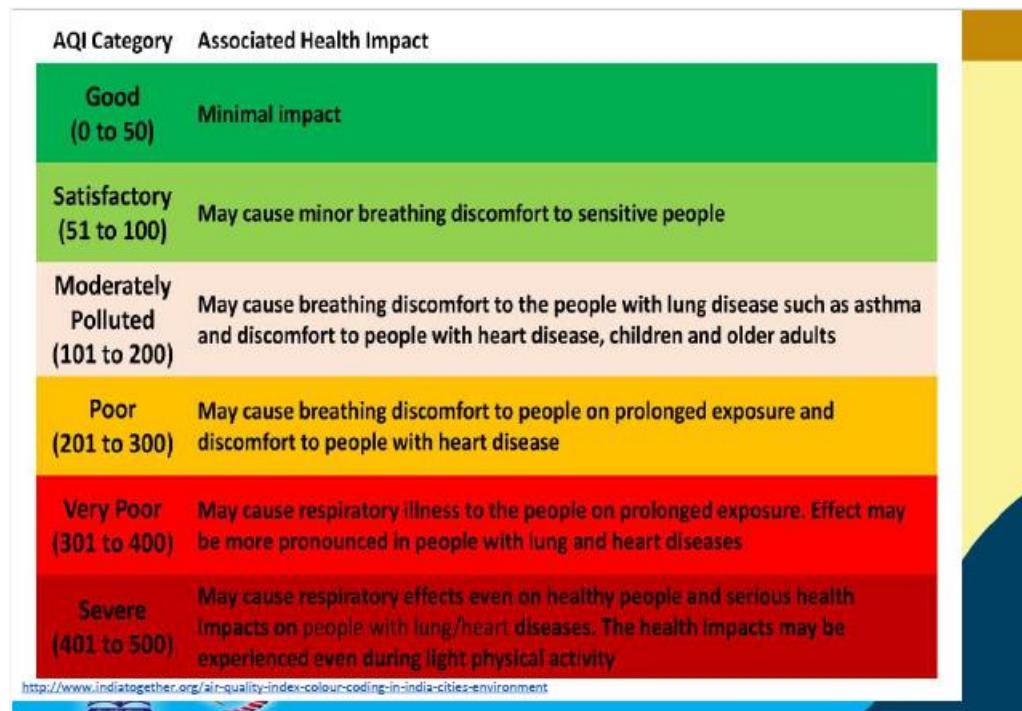
Match the following AQI categories with their associated health impacts.

- | AQI Category | Health impacts   |
|--------------|--|
| A. 0 – 50    | i. May cause minor breathing discomfort to sensitive people  |
| B. 51 - 100  | ii. Minimal impact   |
| C. 101 - 200 | iii. May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease  |
| D. 201-300   | iv. May cause breathing discomfort to people with lung diseases such as asthma and discomfort to people with heart disease, children, and older adults |
- a. A-ii, B-i, C-iv, D-iii  
b. A-i, B-ii, C-iv, D-iii  
c. A-ii, B-i, C-iii, D-iv  
d. A-i, B-ii, C-iii, D-iv



**Correct Answer: a**

**Detailed Solution:**



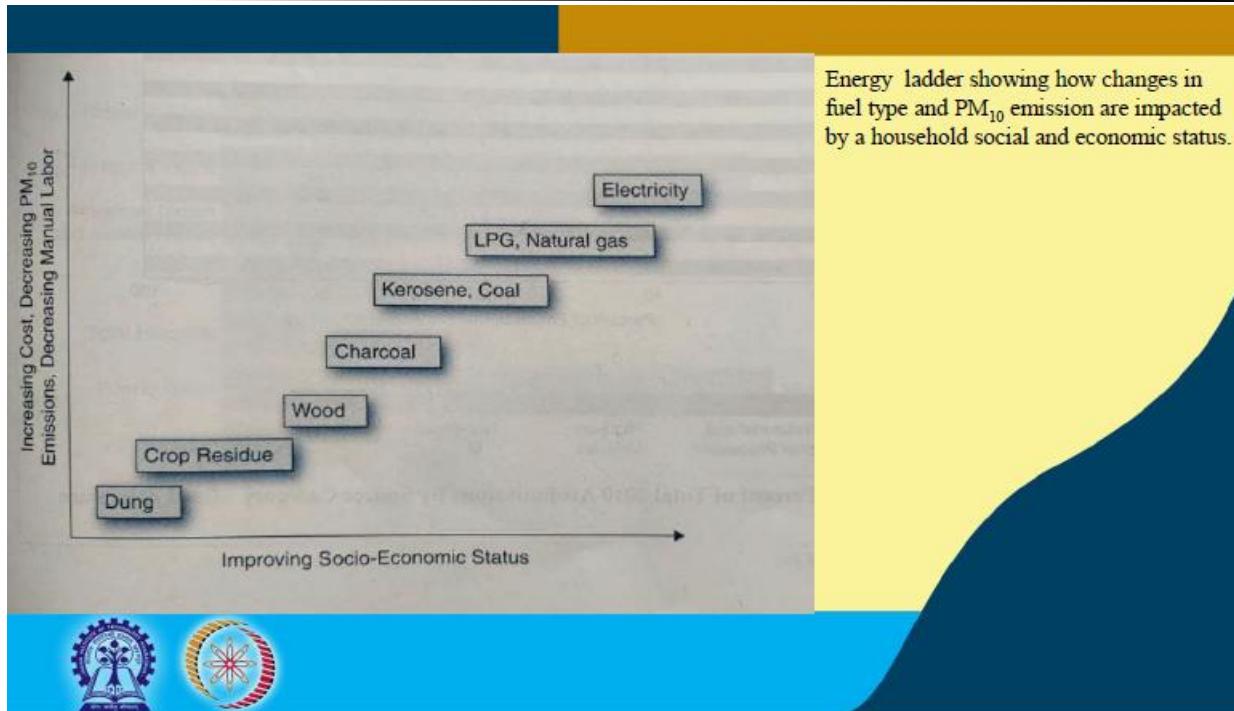
#### **QUESTION 4:**

Identify the correct order in which the fuels are arranged in decreasing PM<sub>10</sub> emissions.

- Crop residue – Wood – Coal – Natural gas – Electricity
- Electricity – Natural gas – Coal – Wood – Crop residue
- Crop residue – Coal – Wood – Natural gas – Electricity
- Wood – Crop residue – Coal – Natural gas – Electricity

**Correct Answer: a**

**Detailed Solution:**



### **QUESTION 5:**

A dry air parcel rising in the atmosphere cools at a dry adiabatic lapse rate of \_\_\_\_\_.

- a. 4.5 °C/km
- b. 6.9 °C/km
- c. 7.6 °C/km
- d. 9.8 °C/km

**Correct Answer: d**

**Detailed Solution:**



### Important Terms to Understand the Vertical Mixing and Stability of Air

Term	Description
Dry adiabatic lapse rate	Adiabatic processes are ones where no transfer of heat or mass occurs across the boundaries of the air parcel. A dry air parcel rising in the atmosphere cools at a <b>dry adiabatic lapse rate</b> of $9.8^{\circ}\text{C}/\text{km}$ . A dry parcel sinking in the atmosphere heats at a rate of $9.8^{\circ}\text{C}/\text{km}$ .



#### **QUESTION 6:**

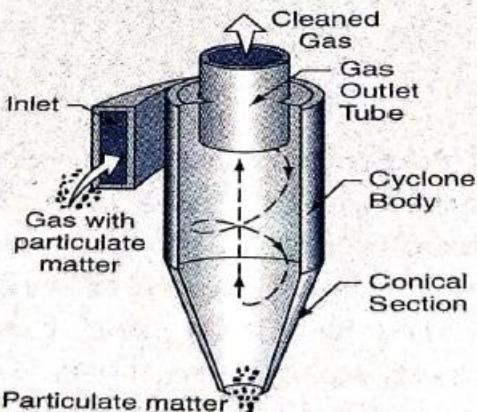
Which air pollution control technology utilizes centrifugal forces to remove particulate pollutants?

- a. Electrostatic precipitator
- b. Venturi scrubber
- c. Biofilter
- d. Cyclone separator

**Correct Answer: d**

**Detailed Solution:**

In a cyclone, particulate pollutants enter with the gas and are removed by centrifugal forces because the particles have more momentum and cannot turn with the gas. The air moves in a helical pattern. Particles that impact the cyclone outer wall then fall by gravity into a hopper where they can be collected.



Mihelcic and Zimmerman, 2014

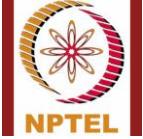
### **QUESTION 7:**

Which air pollutant is generated as a result of incomplete combustion of fuels?

- Particulate matter
- Carbon monoxide
- Nitrogen oxides
- Sulfur dioxide

**Correct Answer: b**

**Detailed Solution:**



Sources, Health Effects, and Other Information Associated with Criteria Air Pollutants (adapted from EPA, 2012a).			
Pollutant	Sources	Health Effects	Other
Carbon monoxide (CO)	Fuel combustion (especially from vehicles)	Short-term exposures can aggravate heart or lung disease leading to respiratory symptoms, increased use of medication, hospital admission, emergency room visits, and premature mortality.	Produced from incomplete combustion of fuels, usually arising from an insufficient amount of air for the amount of fuel. Inadequate air-to-fuel ratio can be due to poorly operated or maintained equipment, airflow limitations, or low temperatures. While high levels are rarely encountered in the ambient atmosphere, asphyxiation can occur in indoor environments, often through a combination of poorly functioning heating systems and inadequate ventilation.

### **QUESTION 8:**

Which of the following is not a greenhouse gas?

- a. Methane
- b. Hydrogen
- c. Carbon dioxide
- d. Hydrofluorocarbons

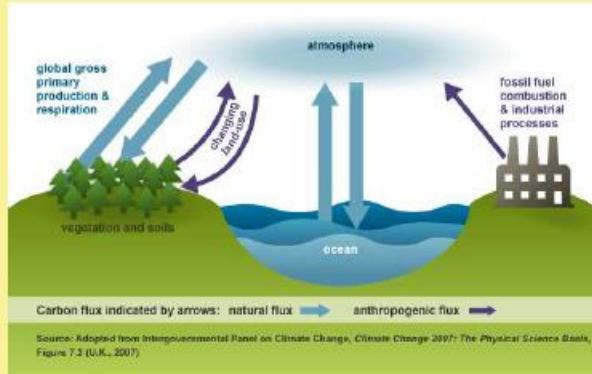
**Correct Answer: b**

**Detailed Solution:**

### What are the types of greenhouse gases?

Several major greenhouse gases that result from human activity are included in U.S. and international estimates of greenhouse gas emissions:

- Carbon dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrous oxide (N<sub>2</sub>O)
- Industrial gases:
  - Hydrofluorocarbons (HFCs)
  - Perfluorocarbons (PFCs)
  - Sulfur hexafluoride (SF<sub>6</sub>)
  - Nitrogen trifluoride (NF<sub>3</sub>)



### **QUESTION 9:**

What is the range of average environmental lapse rate in the troposphere?

- a. 3 – 4 °C/km
- b. 6 – 7 °C/km
- c. 9 – 8 °C/km
- d. 2 – 3 °C/km

**Correct Answer: b**

**Detailed Solution:**



### Important Terms to Understand the Vertical Mixing and Stability of Air

Term	Description
Lapse rates	By definition, the <b>lapse rate (<math>\Gamma</math>)</b> is the ratio of the decrease in air temperature with increase in height ( $\Gamma = - \Delta T / \Delta z$ ). It describes the lapse in temperature with altitude. A positive lapse rate is one where the temperature decreases with height. A negative lapse rate is one where the temperature increases with height. In the troposphere, the average environmental lapse rate is $6-7^{\circ} \text{C}/\text{km}$ increase in altitude but can vary widely locally. Remember, lapse rates are positive when the temperature decreases with altitude.



### **QUESTION 10:**

State whether the following statement is True/False.

“Rural stoves that use biomass cakes, fuelwood, and trash as cooking fuel are major sources of air pollution in India since they produce smoke and numerous indoor air pollutants at concentrations five times higher than coal.”

- a. True
- b. False

**Correct Answer: a**

**Detailed Solution:**



• A rural stove uses biomass cakes, fuelwood and trash as cooking fuel. Surveys suggest over 100 million households in India use such stoves (chullahs) every day, 2–3 times a day.  
• It is a major source of air pollution in India, and produces smoke and numerous indoor air pollutants at concentrations 5 times higher than coal. Clean burning fuels and electricity are unavailable in rural parts and small towns of India because of poor rural highways and limited energy generation infrastructure.

wikipedia.org



### **QUESTION 11:**

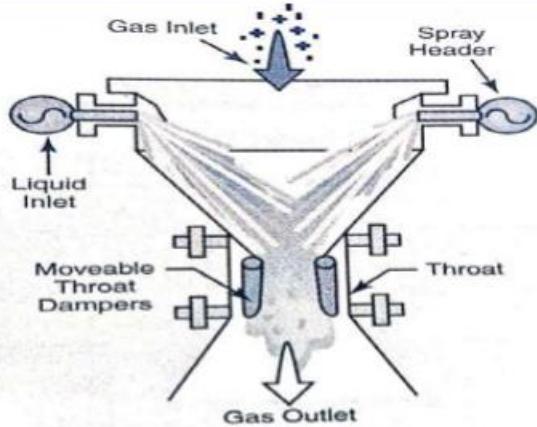
Which of the following air pollutants can be removed by a venturi scrubber?

- a. Particulate matter
- b. SO<sub>2</sub>
- c. HCl
- d. All the above

**Correct Answer: d**

**Detailed Solution:**

In a venturi scrubber, particulate matter and other pollutants such as  $\text{SO}_2$  and HCl can be removed together by impaction of airborne pollutants on water droplets. A water spray can be added by several methods, including injection into flowing gas.



Mihelcic and Zimmerman, 2014

### **QUESTION 12:**

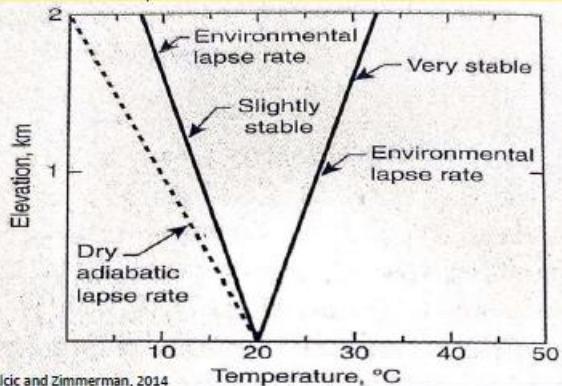
Which atmospheric condition occurs when the environmental lapse rate is the same as the dry adiabatic lapse rate?

- Stable condition
- Unstable condition
- Neutral stability
- None of the above

**Correct Answer: c**

**Detailed Solution:**

During stable conditions, vertical movement of an air parcel is discouraged. Under very stable conditions, a cooler layer of air near the land surface is capped by an upper warmer air layer. This condition is called an inversion and prevents vertical motion of an air parcel.



Mihelcic and Zimmerman, 2014



### QUESTION 13:

Noise is measured in \_\_\_\_\_ units.

- Pascal
- Siemen
- Decibel
- Ampere

**Correct Answer: c**

**Detailed Solution:**



### Sound

- Sound is a vibration that propagates as a mechanical wave of pressure and displacement, through some medium (i.e. air or water).
- Sound refers to only those vibrations with frequencies that are within the range of hearing for human.

### Noise

- Noise is basically any unwanted sound.
- It is measured in dB units.



### **QUESTION 14:**

What are the long-term effects of climate change/global warming?

- a. Decrease in sea ice and an increase in permafrost thawing
- b. Increase in heat waves and heavy precipitation
- c. Decreased water resources in semi-arid regions
- d. All the above

**Correct Answer: d**

**Detailed Solution:**

### What are the long-term effects of climate change/global warming ?

Scientists have predicted that long-term effects of climate change will include a decrease in sea ice and an increase in permafrost thawing, an increase in heat waves and heavy precipitation, and decreased water resources in semi-arid regions.



#### **QUESTION 15:**

State whether the following statement is True/False.

“A positive lapse rate is one where the temperature increases with height, whereas a negative lapse rate is one where the temperature decreases with height.”

- a. True
- b. False

**Correct Answer: b**

**Detailed Solution:**



### Important Terms to Understand the Vertical Mixing and Stability of Air

Term	Description
Lapse rates	By definition, the <b>lapse rate</b> ( $\Gamma$ ) is the ratio of the decrease in air temperature with increase in height ( $\Gamma = - \Delta T / \Delta z$ ). It describes the lapse in temperature with altitude. A positive lapse rate is one where the temperature decreases with height. A negative lapse rate is one where the temperature increases with height. In the troposphere, the average environmental lapse rate is $6-7^{\circ} \text{C/km}$ increase in altitude but can vary widely locally. Remember, lapse rates are positive when the temperature decreases with altitude.



\*\*\*\*\*END\*\*\*\*\*

**Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts**

**Assignment- 12**

TYPE OF QUESTION: MCQ/MSQ

**Number of questions: 15**

**Total Marks 15 x 2 = 30**

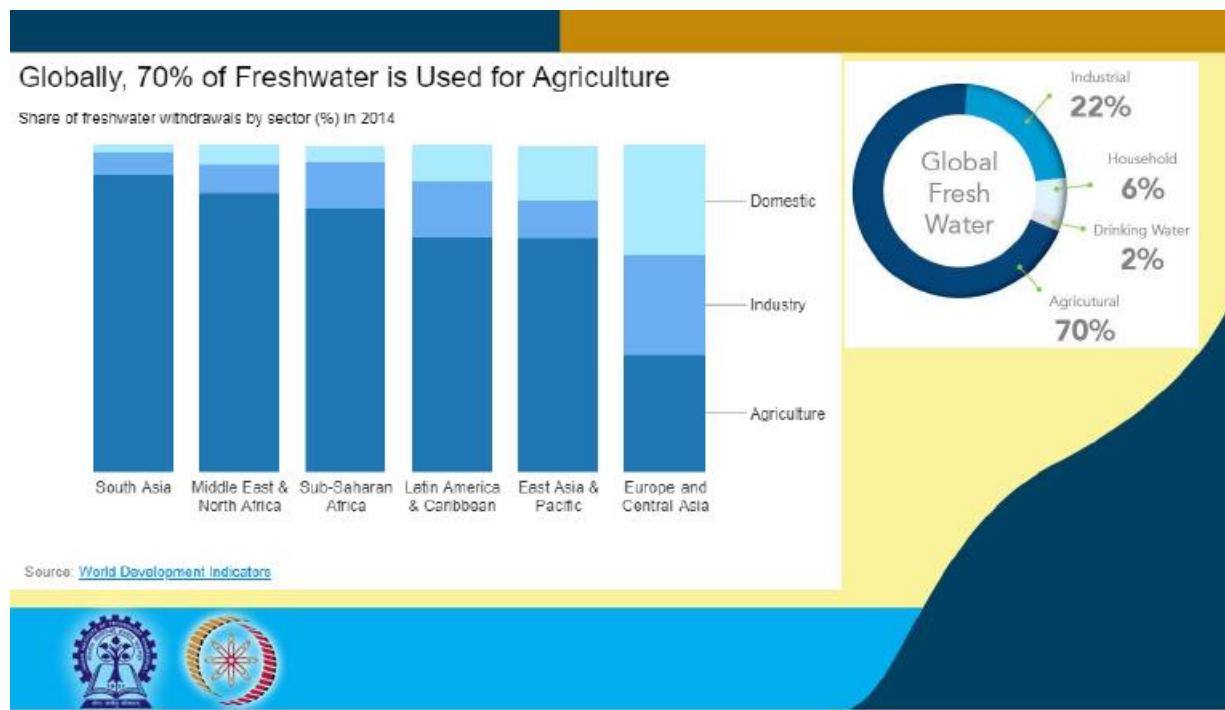
**QUESTION 1:**

Which sector has the highest share of freshwater withdrawals globally as per World Development Indicators (2014)?

- a. Household
- b. Industry
- c. Agriculture
- d. Household

**Correct Answer: c**

**Detailed Solution:**



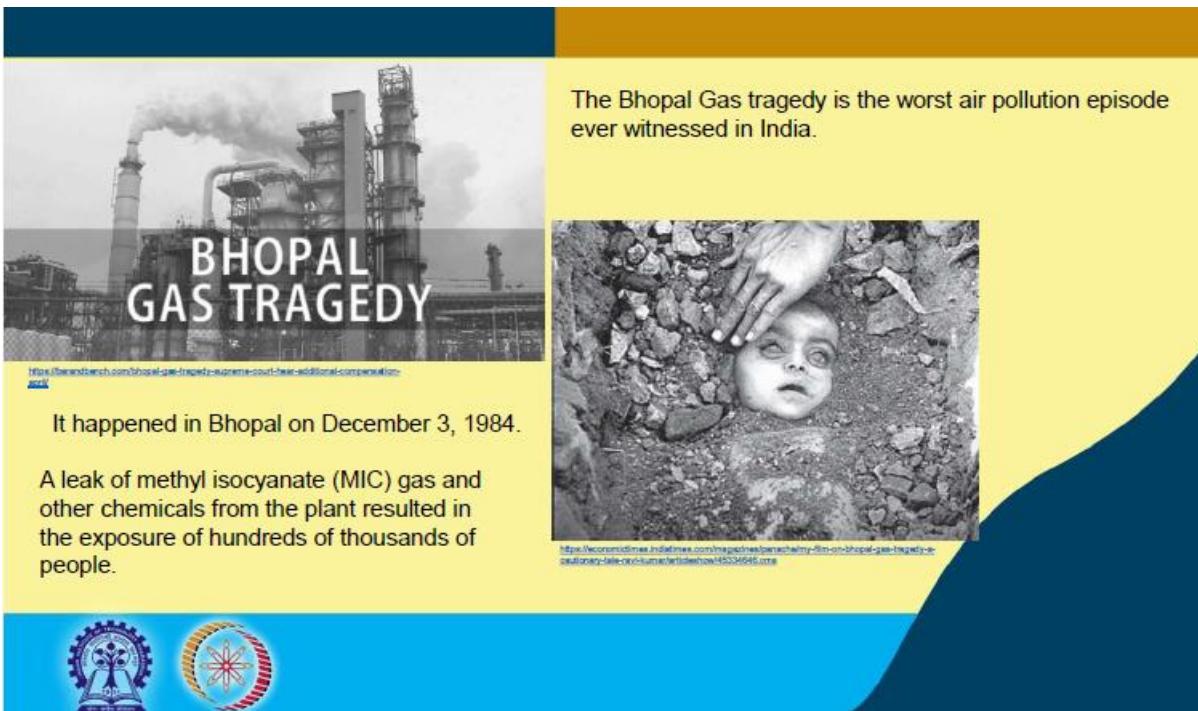
### **QUESTION 2:**

The leakage of which gas caused the Bhopal Gas Tragedy in 1984?

- a. Methyl cyanate
- b. Methyl isocyanate
- c. Methyl cyanide
- d. Methyl isocyanide

**Correct Answer: b**

**Detailed Solution:**



The infographic is divided into two main sections. The left section shows a black and white photograph of an industrial facility with tall smokestacks emitting smoke, overlaid with the text "BHOPAL GAS TRAGEDY". Below the image is a link: [&gt;&gt;](https://www.bing.com/search?q=bhopal+gas+tragedy+supremo+court+hear+additional+compensation+). To the right, a yellow box contains the text: "The Bhopal Gas tragedy is the worst air pollution episode ever witnessed in India." Below this is another black and white photograph showing a person's face partially buried in a pile of debris or rubble. A hand is visible above the head, suggesting rescue or recovery efforts. A link at the bottom of this section is: [&gt;&gt;](https://economictimes.indiatimes.com/magazines/scroll/why-its-on-bhopal-gas-tragedy-cautious-laws-are-vital/articleshow/45034645.cms).

### **QUESTION 3:**

Which of the following is/are the main reason(s) for the water shortage experienced in Cape town during 2017-2018?

- a. Lack of rainfall
- b. High water consumption
- c. Lack of investment in water supply capacity
- d. All the above

**Correct Answer: d**

**Detailed Solution:**

- The recent water shortages have been mainly caused by a lack of rainfall, and exacerbated by other factors, such as high consumption and lack of investment in water supply capacity.
- Freshwater supply (rainfall and groundwater combined) to the Western Cape region is sensitive to small changes in rainfall. Since 2015, the rainfall has been abnormally low.



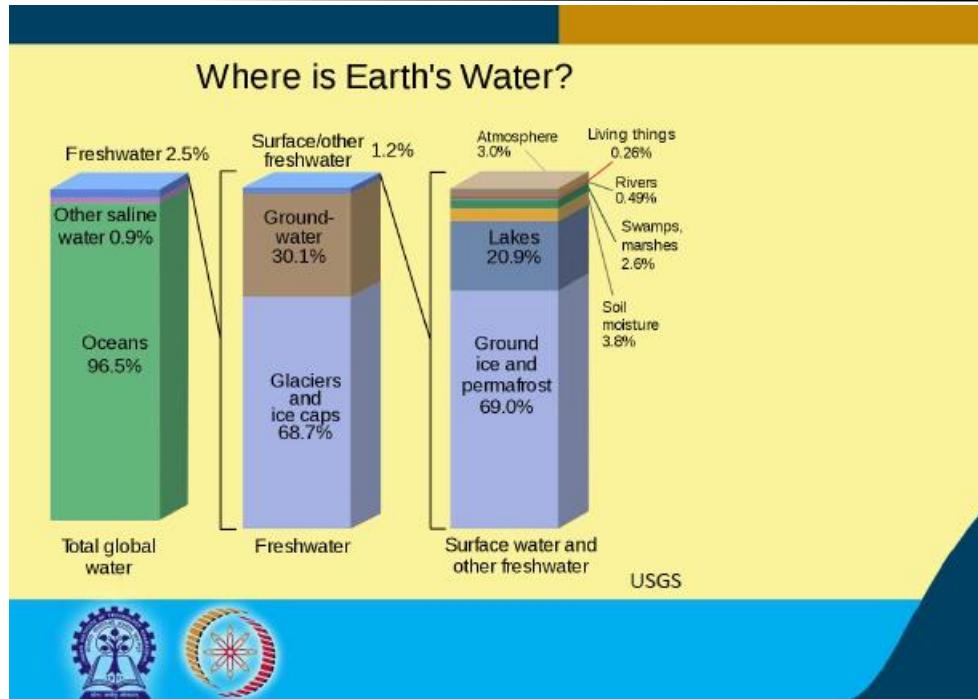
#### **QUESTION 4:**

What percentage of the total global water is fresh water?

- a. 96.5 %
- b. 2.5 %
- c. 0.9 %
- d. 30.1 %

**Correct Answer: b**

**Detailed Solution:**



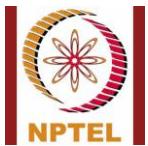
#### **QUESTION 5:**

Identify the correct arrangement of countries from higher to lower water footprint per capita as per the report of the Australian Museum.

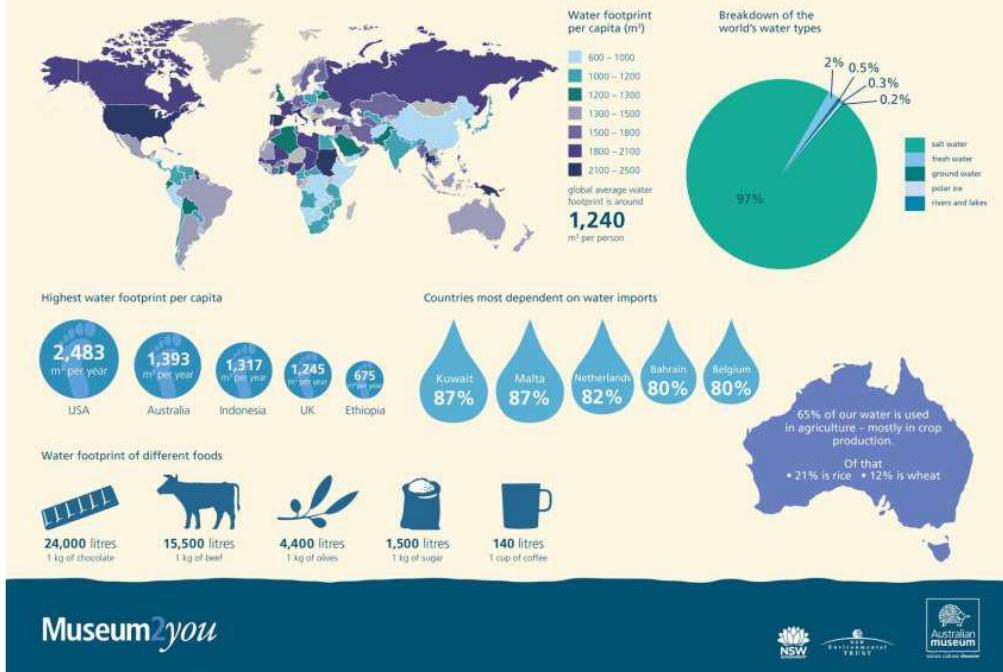
- Indonesia – UK – USA – Australia
- USA – Indonesia – UK – Australia
- USA – Australia – Indonesia – UK
- USA – Indonesia – UK – Australia

**Correct Answer: c**

**Detailed Solution:**



## World Water Use



## **QUESTION 6:**

1 gallon of water equals \_\_\_\_\_.

- a. 1.7 liters
  - b. 2.7 liters
  - c. 3.7 liters
  - d. 4.5 liters

**Correct Answer: c**

## Detailed Solution:

### Fundamental unit of Volume

## **QUESTION 7:**

Which pesticide was the final product from the Union Carbide plant of Bhopal?

- a. Methylamine
  - b. Phosgene
  - c. 1-naphthol
  - d. Carbaryl

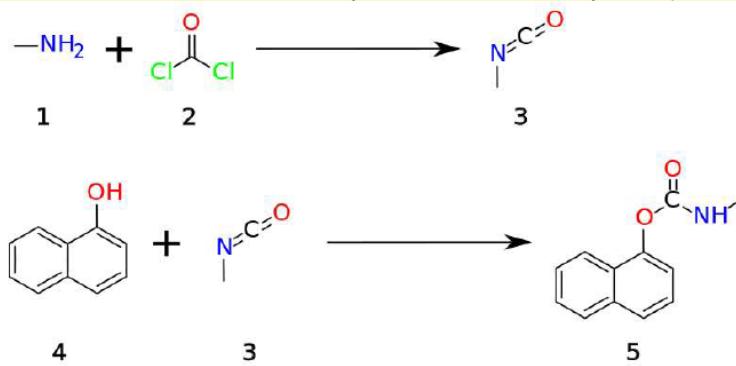
**Correct Answer: d**

**Detailed Solution:**

In 1969, through its subsidiary UCIL, UCC leased land from the Indian state of Madhya Pradesh and got to work creating a new factory in the city of Bhopal.

The company built the plant in Bhopal because of its central location and access to transport infrastructure. The plant was initially approved only for formulation of pesticides from component chemicals, such as MIC(methyl iso- cyanide).

The chemical process employed in the Bhopal plant had methylamine reacting with phosgene to form MIC, which was then reacted with 1-naphthol to form the final product, carbaryl.



Methylamine (1) reacts with phosgene (2) producing methyl isocyanate (3) which reacts with 1-naphthol (4) to yield carbaryl (5)

### **QUESTION 8:**

Harvested food eaten by pests is an example of food loss and waste in \_\_\_\_\_ process of Food Supply Chain.

- a. Production
- b. Handling and storage
- c. Processing and packaging
- d. Consumption

**Correct Answer: b**

**Detailed Solution:**



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## Indian Institute of Technology Kharagpur



### Examples of Food Loss and Waste along the Food Supply Chain (Not Exhaustive)

PRODUCTION	HANDLING AND STORAGE	PROCESSING AND PACKAGING	DISTRIBUTION AND MARKET	CONSUMPTION
<i>During or immediately after harvesting on the farm</i>	<i>After leaving the farm for handling, storage, and transportation</i>	<i>During industrial or domestic processing and/or packaging</i>	<i>During distribution to markets, including at wholesale and retail markets</i>	<i>In the home or business of the consumer, including restaurants and caterers</i>
<ul style="list-style-type: none"><li>■ Fruits discarded due to bruising during picking</li><li>■ Crops sorted out post-harvest for not meeting cosmetic standards</li><li>■ Crops left behind in fields due to poor mechanical harvesting or drops in prices</li><li>■ Fish discarded during fishing operations</li></ul>	<ul style="list-style-type: none"><li>■ Harvested food eaten by pests</li><li>■ Harvested food degraded by fungus or disease</li><li>■ Fish that are spilled or degraded after landing</li></ul>	<ul style="list-style-type: none"><li>■ Milk spilled during pasteurization and processing</li><li>■ Food sorted out as not suitable for processing</li><li>■ Livestock trimming during slaughtering and industrial processing</li><li>■ Fish spilled or damaged during canning or smoking</li></ul>	<ul style="list-style-type: none"><li>■ Food sorted out due to quality</li><li>■ Safe food disposed because of going past sell-by date before being purchased</li><li>■ Food spilled or damaged in market</li></ul>	<ul style="list-style-type: none"><li>■ Food sorted out due to quality</li><li>■ Food purchased but not eaten</li><li>■ Food cooked but not eaten</li></ul>

Source: WRI analysis based on FAO (2011).



### **QUESTION 9:**

Which of the following is/are the initiative(s) taken by Cape Town to manage increasing water demand?

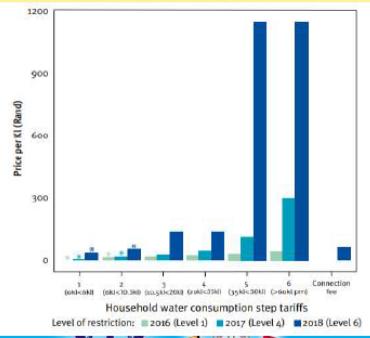
- Strict water restrictions over the period of the crisis.
- Revision of water tariffs
- Installation of Water Management Devices
- All the above

**Correct Answer: d**

**Detailed Solution:**

## 1. Water restrictions

- The city introduced increasingly strict water restrictions over the period of the crisis, which evolved and developed over time as the water shortage became progressively more acute .
- Fines of between R1,000 (\$70) and R10,000 (\$700) were used as punishment for transgressive behavior and high consumption households.
- Water restrictions defined limits on how water could be used, in what quantities and for which purposes. At the most extreme level of restriction implemented, Level 6B, residents were restricted to a maximum of 50 litres (13.2 gallons) of water per person per day.



• Restrictions were revised on an ad-hoc basis by the city, with some revisions taking place within a month of the previous restriction. Under normal circumstances, further restrictions would have to be sanctioned by the Council of the city.

## 2. Tariffs

- The city operates on a step tariff payment system for water, in existence before the current water crisis.
  - In the system, each additional unit of water becomes more expensive as greater volumes are used.
  - Different rates are applied based on the level of water restrictions currently active, and households are also subject to a sanitation charge, calculated as a percentage of their water consumption for the month.
  - Under normal circumstances, the city is limited to a single adjustment of tariffs per year as part of their budget review, which comes into effect annually in July.
  - In response to the water crisis, tariffs were increased significantly from 2016 until late 2018 in order to reduce water demand.
- Tariffs were not downgraded again until 1 October 2018.





### 3. Water Management Devices

- A Water Management Device (WMD) is equipment that can be installed to a water supply pipe to enforce a set daily limit of water for a property. After the maximum withdrawal is reached for the day, the water is reduced to a trickle until the following day when service is resumed.
- Originally used to manage debt and unfixed leaks from indigent houses over many years, the City rolled out WMDs throughout 2017 as part of a voluntary program whereby indigent households could choose to have a WMD installed without charge, combined with a one-off house leakage fix and an agreement to write off historic water debt.



### **QUESTION 10:**

As per WRI analysis based on FAO (2007 data), which of the following regions has the highest share in global food loss and waste?

- Industrialized Asia
- Europe
- Latin America
- Sub-Saharan Africa

**Correct Answer: a**

**Detailed Solution:**



### **QUESTION 11:**

State whether the following statement is True/False.

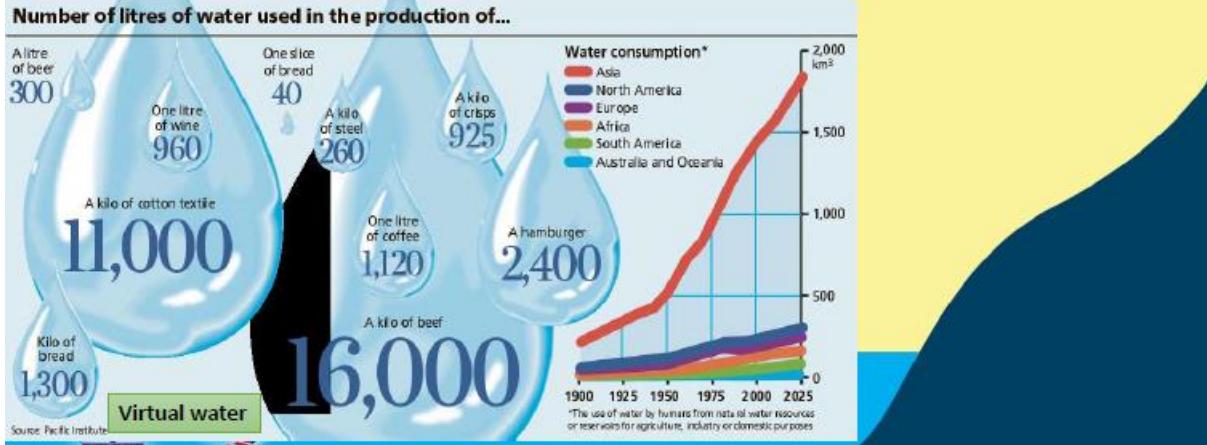
“Water that is consumed during the production of a commodity is termed as virtual water.”

- a. True
- b. False

**Correct Answer: a**

**Detailed Solution:**

- Water usage by urban, industrial, and agricultural users is also changing, putting more pressure on the water supplies.
- ‘Virtual water’, water used in the production of a commodity that is then exported out of South Africa, has emerged as a key factor – **South Africa is a net exporter of virtual water.**



### **QUESTION 12:**

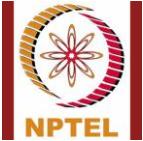
State whether the following statement is True/False.

“Approximately 90% of the floating marine debris consists of plastic, with nearly 62% of this plastic comprising food and beverage packaging.”

- True
- False

**Correct Answer: a**

**Detailed Solution:**



- Marine litter comes in all shapes and sizes and, depending on the material, could be damaging to human health.
- Some 90 percent of floating marine debris is plastic, of which nearly 62 percent is food and beverage packaging. Although plastics have been mass-produced for only about 60 years, they persist in open waters for decades and even centuries.
- Even plastics designed to be biodegradable may not fully decompose since they depend on factors such as exposure to light, oxygen, and temperature which are scarce in ocean depths.
- Smaller particles of plastic from manufacturing processes could also be difficult to account for and nearly impossible to extract.



### **QUESTION 13:**

Match the following waste collection bins to their corresponding waste material based on the source separation scheme adopted by Panaji, India.

- |                |                        |
|----------------|------------------------|
| A. Green bins  | i. Non-recyclables     |
| B. Pink bins   | ii. Plastics           |
| C. Orange bins | iii. Paper and cartons |
| D. White bins  | iv. Wet waste          |
- a. A-i, B-ii, C-iii, D-iv  
b. A-iv, B-iii, C-ii, D-i  
c. A-i, B-ii, C-iv, D-iii  
d. A-iv, B-ii, C-i, D-iii

**Correct Answer: b**

**Detailed Solution:**



## Source Separation Overview

Panaji generated 50 tonnes of waste daily in 2017. Residential waste is source separated into five streams through a system of colored bins:

- Green bins: Wet waste
- Black or grey bins: Glass and metals
- Pink bins: Paper and cartons
- Orange bins: Plastics
- White bins: Non recyclables



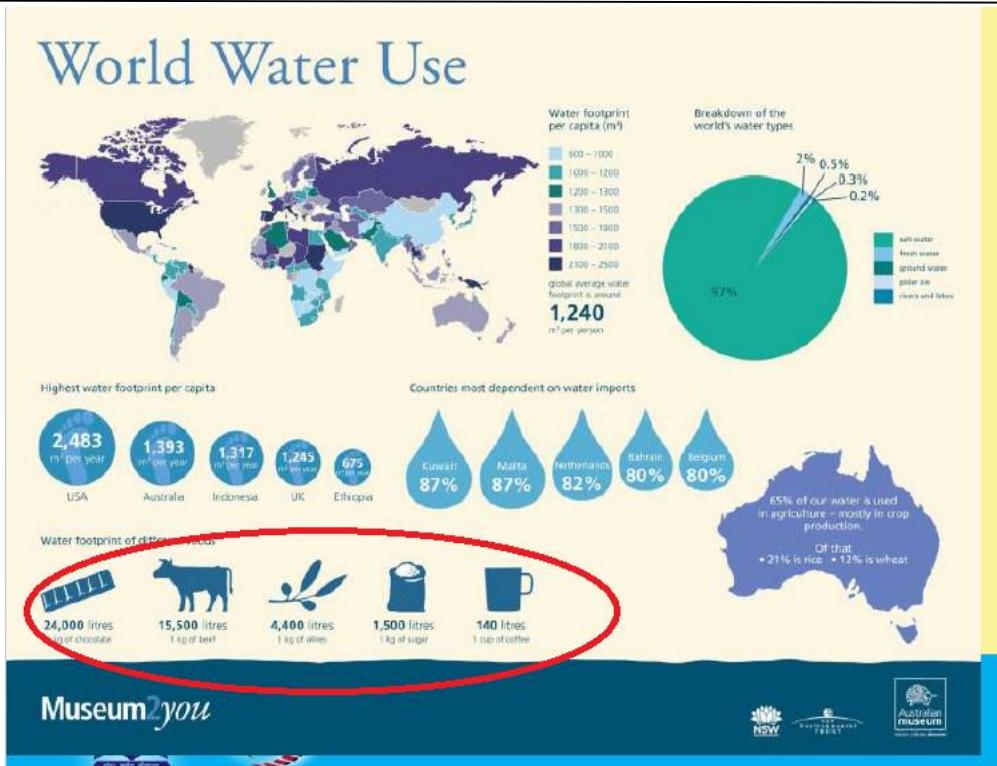
### **QUESTION 14:**

Which of the following food items has the lowest water footprint?

- a. 1 kg of chocolate
- b. 1 kg of beef
- c. 1 kg of sugar
- d. 1 cup of coffee

**Correct Answer: d**

**Detailed Solution:**



## **QUESTION 15:**

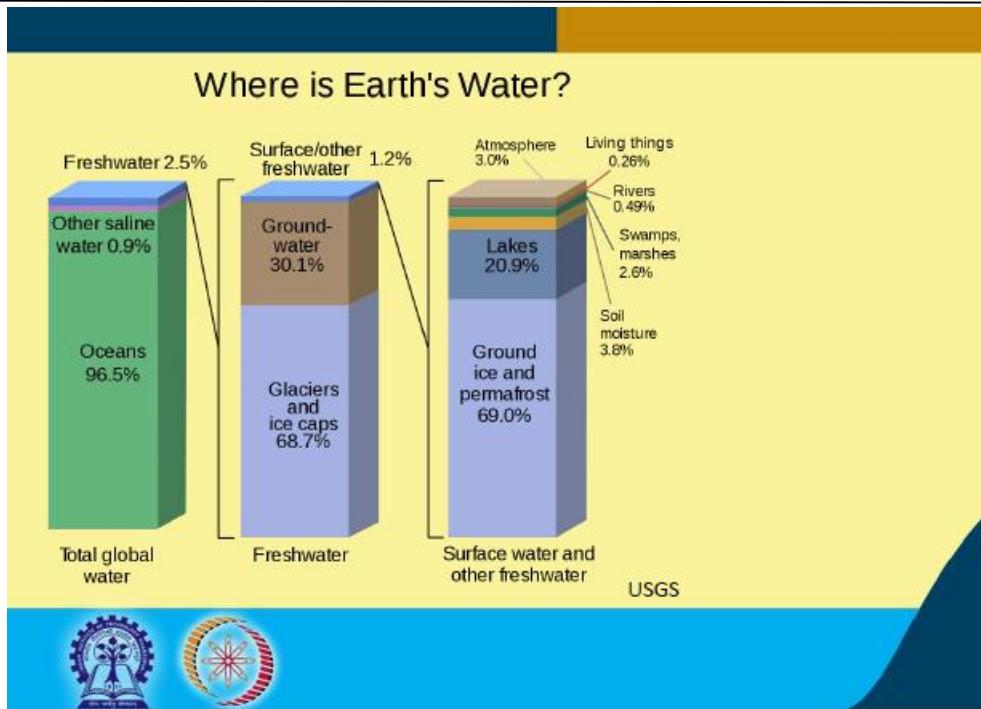
State whether the following statement is True/False.

“Groundwater accounts for a major portion of the freshwater reserve.”

- a. True
  - b. False

**Correct Answer: b**

### Detailed Solution:



\*\*\*\*\*END\*\*\*\*\*