ANSWERS TO GENERAL PAPER, 2009

1. **A:** viruses are **obligate intra-cellular parasites**. This implies that they only grow, multiply and survive inside **living cells** only. They do not posses any of the characteristics of living things outside a host cell (e.g. reproduction, growth, respiration etc). However, once they gain entry into a host cell, they exhibit the characteristic of living thing. Thus they possess the characteristics of both living and non-living things.
Viruses cannot grow on dead cells
Certain viruses due to their shaped, (icosahedral) may be crystallized!

2 **C: Putrefaction** (decaying) adds nitrogen to the soil from dead or dying organic matter. Putrefaction is brought about by putrefying bacteria and fungi (**saprophytes**). These saprophytic organisms convert dead plant and animals matter into simple substances like carbon dioxide, water and ammonia (a nitrogen-containing organic compound). Ammonia is converted to **nitrates** by **nitrifying bacteria**. *Nitrosomonas* converts ammonia to nitrites, while *Nitrobacter* converts **nitrites** to nitrates.
Nitrogen fixation is the process whereby atmospheric nitrogen (nitrogen in air) is incorporated or fixed into the soil. This is achieved by two means
(a). The action of thunderstorms
(b). Nitrogen fixing bacteria.
During **thunderstorms,** nitrogen reacts with atmospheric oxygen to produce nitric oxide. This is oxidized to nitrogen peroxide which dissolves in rainwater to form organic acids of nitrogen. These enter the soil, combines with mineral salts to form nitrates which are absorbed by plant roots.
Nitrogen-fixing bacteria (eg. *Azotobacter* and *Clostridium*) convert atmospheric nitrogen into amino-compounds (compounds of amino acids) and proteins. Symbiotic bacteria such as *Rhizobium* use atmospheric nitrogen to manufacture amino compounds and proteins which they share with the host plants through the root nodules. When the host plant dies, these nitrogenous compounds in the root nodules are converted to nitrites.
Denitrification is the process by which nitrates are lost from the soil, this is by conversion of the nitrates to gaseous nitrogen (the opposite of nitrogen fixation). This reduces the nitrogen content of the soil and its fertility. Denitrification is brought about by **denitrifying bacteria.**

3. **C:**
From the work of **James Watson** and **Francis Crick** (1953), we now know that the DNA molecule is a **double helix structure**, composed of repeating units of nucleotides (a nucleotide contains a **pentose sugar, phosphate** and a **nitrogenous base**).
The nitrogenous bases that make up the nucleotides of DNA are Adenine, Guanine, Cytosine and Thymine, are denoted as A, G, C and T respectively.
(**NB**: In RNA, thymine is replaced by Uracil)
Adenine is bound to Thymine by two hydrogen bonds (T–A), while Guanine is bound to Cytosine (C–G) by three hydrogen bonds. This arrangement is called "**base-pairing**" and it is specific.
This may easily be remembered by mnemonic:
"**A**de weds **T**ina" (A–T)
"**G**abriel weds **C**ynthia (G–C)
Note that **DNA** contains the **deoxyribose** sugar, while **RNA** contains the **ribose sugar** respectively.
G–T, T–C and G–A are not part of the Watson-Crick DNA base pair model.
For the work of Watson and Crick, they were awarded the Nobel Prize in 1962, alongside Maurice Wilkins.

4. **A**
Functions of the Liver
(i) Storage of glycogen
(ii) Formation of cholesterol
(iii) Synthesis and excretion of bile
(iv) Storage of vitamins, minerals (e.g. Iron). The liver, alongside the kidneys, activates vitamin D.
(v) Deamination of excess amino acids(catabolism).
(vi) Maintenance of blood glucose level.
(vii) Removal of old, worn-out (senescent) red blood cells
(viii) Synthesis of plasma proteins like albumin.

(ix) Synthesis of blood-clotting factors e.g. the types that are vitamin-K dependent.
(x) Packaging and re-distribution of food absorbed from the small intestines.

NB
(a). The food absorbed from the intestines are transported to the liver via the **hepatic portal vein**
(b). Bile is **synthesized** in the **liver**, but **stored** in the **gall bladder.**

5. **A**
Diesel is a non-volatile liquid and so does not vaporize in significant amounts to cause air pollution. CO, SO and H_2S are air pollutants. CO reduces the oxygen-carry capacity of haemoglobin (the oxygen-transporting pigment of blood) drastically, thereby causing death.

6. **A**
The tongue perceives four basic types of taste; sweet, sour, salty and bitter. The taste receptors are distributed in the following pattern:
- **Sweet** and **salty**: front of tongue
- **Sour**: Side of tongue
- **Bitter**: Back of tongue

7. **A**: the ovaries and testes are organs of reproduction

8. **B**: Biotechnology is directed towards the production of plant and animal species with higher resistance to pests and diseases, better nutritional value and high economic yields.

9. **A**
Complete metamorphosis
Egg → Larva → Pupa (chrysalis) → Adult (Imago).
Examples of insets that undergo **complete metamorphosis** are: butterfly, housefly, moths, mosquito, tse-tse fly, etc.
Incomplete Metamorphosis
Egg → Nymph → Adult (Imago).
Eg. Cockroach, grasshopper, aphids, termites etc.

10. **D.**
Bulb e.g. Onion, garlic, lily.
Stem tuber e.g. Yam, Irish potato.
Rhizome e.g. Ginger, canna lily, ferns, certain grasses,
Runner: e.g. Sweet potato and some grasses.
Sucker e.g. Pineapple, banana, plantain.
Corm e.g. Cocoyam, *Caladium*
Bulbil e.g. *Bryophyllum*, wild yam.

Artificial vegetative propagation includes **cuttings, layering, bud grafting, stem grafting, marcotting** etc.
Cuttings are woody or green parts of stems which when plated, grow roots and develop into new plants.
NB: Cassava is not a stem tuber; it is a **root tuber**. The sweet potato is also a root tuber, though it has the properties of runners.

11. A: **Geotropism** may be demonstrated using a **clinostat.**

12. **B**
Sucrose is a disaccharide sugar containing glucose and fructose in equal amounts.
Glycogen is the storage form of glucose in **animals** (in **plants**, the storage form of glucose is starch). In man, the largest stores are found in the liver and skeletal muscles. Adenosine diphosphate (ADP) is formed from the breakdown of adenosine triphosphate (ATP) by cleavage of one phosphate bond.

13. C

Roughages refer to foods rich in fibre. Corn is rich in fibre, but the flour has be finely ground, such that the fibre particles are powdered.

14. **D.**

According to the World Health Organization's definition:

"Health is a state of complete physical, mental and social well-being, and not just the absence of disease or deformities".

This is, a **healthy person** is physically active, mentally and psychologically stable and relates with people.

15. **D**

The stages of cell division may be remembered with the pneumonic **P**illow-**MAT**.

P → Prophase
M → Metaphase
A → Anaphase
T → Telophase

See a biology textbook to know what happens at each stage!

16. **C.**

Iodine and ammonium chloride sublime.

17. NB: both masses in '**grams**' and in '**percentage**' can be used to calculate empirical formula!

	C		H		O
	2.02		0.35		2.68
Mole ratio	$\frac{2.02}{12}$	:	$\frac{0.35}{1}$	:	$\frac{2.68}{16}$
	= 0.168		0.35		0.168

Divide by smallest no:

$$\frac{0.168}{0.168} : \frac{0.35}{0.168} : \frac{0.168}{0.168}$$

$$= 1 : 2.1 : 1$$

Empirical formula = CH_2O

(Empirical formula)n = Molecular formula/molecular weight.....(i)

$(CH_2O)n = M.W.$

$(12 + 2 \times 1 + 16)n = 90$

$(12 + 2 + 16)n = 90$

$30n = 90$

$n = 90/30 = 3$

Substituting n = 3 in equation (i) above

$(CH_2O)_3$ = Molecular Formula

$C_3H_6O_3$ = M.F.

C

18. **D**

Isotopy is a phenomenon whereby atoms of the same element have **the same atomic number** but **different mass number** due to **unequal number of neutrons**.

NB

(i). Protons + neutrons = Mass Number
(ii). Number of protons = Atomic Number
(iii). Electrons are responsible for the **chemical properties** of atoms
(iv). Protons and Neutrons are responsible for the **physical properties**.
(v). Protons are positively charged, electrons are negatively charged, while the neutrons are neutral.

(vi). The protons and neutrons are found in the nucleus, while the electrons are found in the shells or orbits.

(vii). The nucleus has an overall **positive charge.** The atom is **neutral.**

(viii). Ions are formed when here is a gain or loss of electrons by atoms. Cations (+ve) are formed by loss of electrons while anions (-ve) are formed by the gain of electrons.

(ix). for iso-electronic species, the ionic radius decreases with increasing effective nuclear charge.

(x). For different ionic states of the same elements, the ionic radius decreases with increasing effective nuclear charge. Thus, Fe^{3+} has a smaller ionic radius compared toFe^{2+}.

) D.

"***chloros***" in Greek means yellowish green; just like leaves.

NB: Chlorine can be tested for by one of two ways

(i). Damp blue litmus paper test: Chlorine turns damp blue litmus paper pink, and then leaches it (chlorine bleaches by oxidation). Compare this to the action of HCl gas on damp blue litmus paper: HCl gas turns damp blue litmus paper red, without bleaching it.

(ii). Starch-iodide paper test: Chlorine turns damp starch-iodide paper dark blue. This is due to the displacement of iodine which then turns the starch blue-black.

0. $CaC_2 + H_2O \rightarrow C_2H_2 + CaO$

1 mole 1 mole

A mole of CaC_2 (calcium carbide) → 1 mole of C_2H_2 (ethyne)

In "**grams**"

$(40 + 2 \times 12)$g of $CaC_2 \rightarrow (2 \times 12 + 2 \times 1)$g of C_2H_2

64g of $CaC_2 \rightarrow$ 26g of C_2H_2

1 mole of C_2H_2 occupies $22.4dm^3$ at S.T.P.

This volume ($22.4dm^3$) is equivalent to 26g (or 1 mole) of C_2H_2

$\therefore$ 64g of $CaC_2 \rightarrow$ $22.4dm^3$ of C_2H_2

xg of $CaC_2 \rightarrow$ $1.12dm^3$ of C_2H_2?

$$x = \frac{64 \times 1.12}{22.4} = 3.2g$$

NB: **$22.4dm^3$, 26g or 6.02×10^{23} molecules** are different ways of expressing **1 mole of C_2H_2** gas at S.T.P. For another gas this is also true, except for the value of the mass, e.g. one mole of Oxygen gas at S.T.P. is equivalent to $22.4dm^3$, 32g or 6.02×10^{23} molecules.

"Solubility" is commonly expressed in $mol.dm^3$ i.e. the number of moles of solute in $1dm^3$ or 1 litre of the **solution**.

Form the question:

$5.3g \rightarrow 50cm^3$

$x\,g \rightarrow 1000cm^3$ ($1dm^3$)

$$x = \frac{5.3 \times 1000}{50} = 106g$$

106g of $AgNO_3$ would be found dissolved in $1000cm^3$ ($1dm^3$) of solution.

(NB: $AgNO_3 = 170$ g/mol)

$$\text{Number of moles in } 1000cm^3 = \frac{mass}{molar\ mass}$$

$$= \frac{106}{170} = 0.6235 \approx 0.624\,mol.dm^{-3}$$

D

NB: For questions that you don't get the exact value as in the options, pick the option closest to your answer. e.g. 0.623 is closes to 0.624.

A

Sodium trioxocarbonate (IV), Na_2CO_3 does not decompose on heating. Lead trioxocarbonate (IV) is not known. Option D is incorrect because it is not balance!

23. **B**

Neutralization is an **exothermic reaction**. The amount of heat evolved during the combination of hydrogen ion (H^+) and hydroxide ions (OH^-) to form one mole of water is termed "**heat of neutralization**".

24. **C.**

Oxygen, O_2 is **colourless, odourless** and **tasteless**. Other gases which share this property are H_2, CO, etc. Nitrogen (IV) oxide NO_2 is a poisonous reddish-brown gas with an irritating small
Dinitrogen (I) oxide, N_2O is otherwise called **laughing gas**. It is a colourless gas with a faint, pleasant, sickly smell. It has a sweet taste.

25. **C**

Octane Number Rating is used to express the **quality of petrol**. The best quality petrol has an Octane Number close to 100.The worst quality petrol has an octane number close to zero.

Heptane: Octane number = 0

2,2,4 trimethylpentane: Octane number = 100

NB:

(i) The presence of large amounts of long-chain, unbranched hydrocarbons worsen the quality of petrol. The presence of large amounts of short-chain or branched hydrocarbons improves the quality of petrol.

(ii) Long-chain and/or unbranched organic compounds have higher boiling points and are less reactive; short chain and/or branched organic compounds have lower boiling points and are thus more reactive. The proviso for comparison of long chain versus short chain compounds is that they should belong to the same homologous series.

26. **C**

Despite the "**unsaturated**" nature of benzene, it preferentially undergoes **substitution** reactions (not **addition**).

27. **B:**

According to **Pressure Law** (Amonton's Law): ***"The pressure exerted by a fixed volume of a gas is directly proportional to its temperature"***

ie $P \propto T$

$P = KT$

$$K = \frac{P}{T} = cons\tan t$$

$$\Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

The implication of this law here is that high pressures are associated with high temperature. This will further reduce the negligible cohesive force between molecules, making the gas molecules more energetic.

28. **B:**

Aufbau Principle (or Building-up Principle) states that: "When filling electrons into atomic orbitals, electons must go into the orbitals of lower energy before they are filed into orbitals of higher energies". (Just like in building a house, one starts from the foundation, ground level, walls, etc, before the **roof**). Of 3d, 4s, 4p and 4d, 4s has the lowest energy. The energies are in the order

$4s < 3d < 4p < 4d$.

The pattern of filling electrons into energy levels may be understood by memorizing the diagram below.

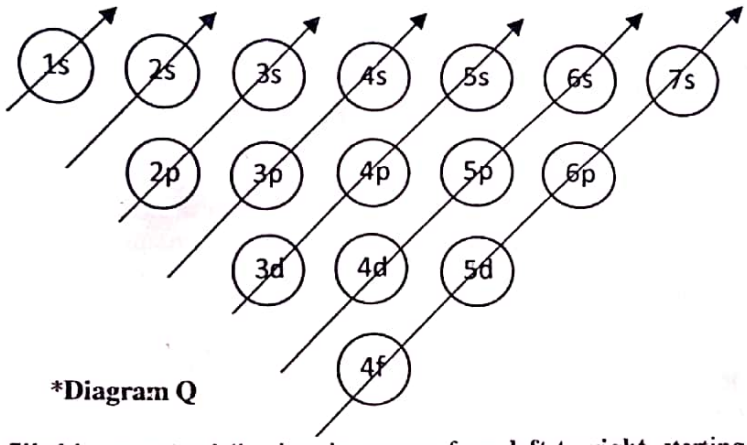


*Diagram Q

Electrons are filled in an order following the arrows from **left to right**, starting from the bottom of the first arrow to the tip and then "jumping" to the bottom of the next arrow and following it to the tip. (Bearing in mind that the s-orbital takes a maximum of 2 electrons, p = 6 electrons, d = 10 electrons, f = 14 electrons).
For example the electronic configuration of Calcium, Ca = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ = 20 electrons. (Compare this electronic configuration to the chart above). The transition metals have the d-orbital in their configuration.

29. **C.**
The process is termed "Eutrophication".

30. **D**
Phenolphthalein is a **basic-range indicator** i.e. It is retains its pink or violet colour in basic solutions. In acidic solutions such as pH = 2.5, it is colourless! It is also a component in **universal indicators**, a solution consisting of a mixture of pH indicators (usually phenolphthalein, methyl red, bromothymol blue, and thymol blue).
Methyl orange is an **acidic-range indicator.** It is orange coloured or yellow in basic solutions, but becomes purple or pink in acidic medium. At end point it changes to pink.

Indicator	pH range	Colour in acidic medium	Colour in basic medium
Methyl orange	3.1 – 4.5	Pink	Yellow
Phenolphthalein	8.0 – 9.8	Colourless	Pink
Methyl red	4.2 – 6.3	Red	Yellow

If an acid is to be titrated against a base, the choice of an indicator is very essential. The table below gives a summary of this.

Type of titration	Indicator used
(A). Strong acid with strong base	Phenolphthalein, methyl orange or methyl red (i.e., any indicator may be used)
(B) Weak acid with strong base	Phenolphthalein
(C) Strong acid with weak base	Methyl orange or Methyl red

31. **A vector quantity** is a physical quantity whose magnitude (size) is measured in a specified direction (e.g. weight, displacement, velocity, acceleration, normal reaction, force, etc). The **weight** of an object is measured from its centre of mass towards the centre of the earth.
On the other hand, a **scalar quantity** has magnitude, but no specific direction (e.g. mass, distance, speed, etc).

D

32. **Work** is done when a force moves through a distance. It is calculated as the product of the force and the distance it travelled.

$$W = F \times s.$$

The cement block was carried vertically through a distance (height). Without this force, the cement block will be resting on the floor with its weight (mg) exerting an action on the floor which exerts an equal but opposite reaction on it.
Lifting the cement vertically through a height, h with a constant velocity entails applying a force, F, equal to the weight, mg though a height, h.

Thus, $W = F \times s$
$= mg \times h$
$= 10 \times 9.8 \times 2.5 = 245J$

B

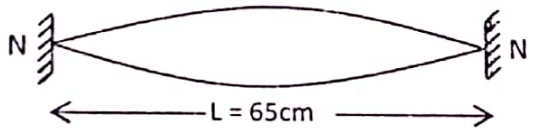
33. Potential energy at a given height is given by

$P.E. = mgh$
$= 75 \times 9.8 \times 10 = 7350J = 7.35kJ$

A

34. $L = 65cm$

The idea is that the guitar string is fixed or closed at both ends and vibrates to produce sound waves when plucked. The fundamental frequency is produced at the lowest vibration mode (First harmonic).



The length corresponds to ½ of a wavelength. Thus: $L = \lambda/2$

The closed end of a string/pipe is the **node** while the open end is the **antinode.**
From node to node: $L = \lambda/2$

From node to antinode: $L = \lambda/4$
From antinode to antinode: $L = \lambda/2$
Therefore, from the diagram above, it is node to node. Hence, $L = \lambda/2$

$\lambda = 2L$

$\lambda = (2 \times 65)cm = 130m,$

D

35. Parallel connection of resistors is given by

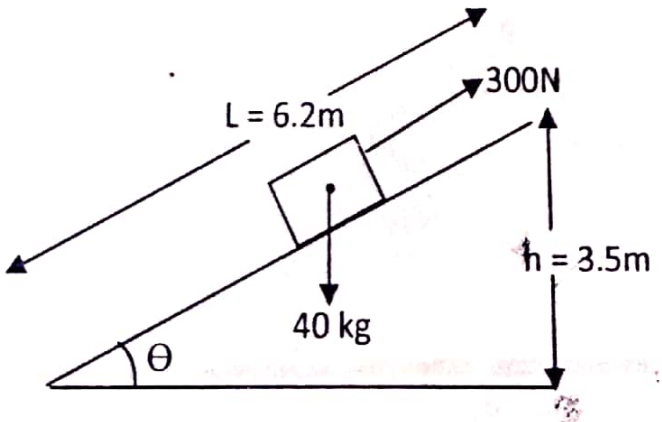
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R} = \frac{1}{8} + \frac{1}{8} = \frac{2}{8}$$

$$R = \frac{8}{2} = 4\,ohms$$

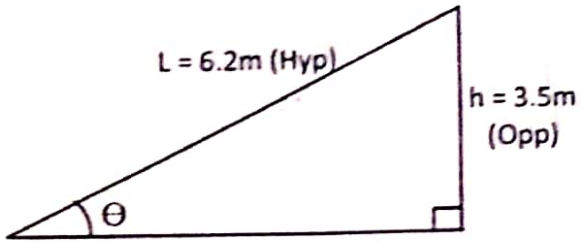
B

36. Depicting the question with the aid of a diagram, we have:



Velocity ratios of inclined plane = $\frac{1}{Sin\,\theta}$

However, we do not know "θ" but we know Length and Height. Re-drawing the diagram and showing the Length and Height only, we have:



Now using the SOH CAH TOA denotations:

$$Sin\theta = \frac{opp}{hyp} = \frac{3.5}{6.2} = 0.5645$$

$$V.R. = \frac{1}{0.5645} = 1.77$$

D

37. **A. The unit of pressure of Nm^{-2}. This is the same as saying: N/m^2**

38. **We use the General gas equation:**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P_1 = 745mmHg, V_1 = 120cm^3, T_1 = 20°C + 273 = 293K
P_2 = Standard pressure = 760mmHg, V_2 = ?, T_2 = Standard temperature = 273K.
Substituting;

$$V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{745\times120\times273}{760\times293}$$

$$= 109.6cm^3$$

D

39. Linear expansivity: $\alpha = \frac{\Delta l}{l_0\Delta t}$

Change in length $(\Delta l) = 30.04 - 30 = 0.04\,cm$

Change in temperature $(\Delta t) = 60^0C$

Original length, l_0 = 30 cm

$$\alpha = \frac{0.04}{30\times60} = 2.22\times10^{-5}\,K^{-1}.$$

B

40. **A**

41 According to Hooke law, F = Ke

$$K = \frac{F}{e} = \frac{1}{0.027} = 37N\,m^{-1}$$

C

42. High centre of gravity implies instability. i.e. a body with a high centre of gravity is unstable in equilibrium, while a with a low centre of gravity is stable.

C

NB: There are 3 types of equilibrium and the following are conditions associated with each.

Stable Equilibrium:

A body is in stable equilibrium when on receiving a slight displacement, it tends to return to its original position.

This occurs for a body with large base and low centre of gravity e.g. a cone resting on its base, a racing car, the beam of an ordinary balance.

Unstable Equilibrium:

A body is in unstable equilibrium when on receiving a slight displacement, it tends to move farther away from its original position. This occurs for a body with small base and high centre of gravity e.g. a cone resting on its vertex, or an egg standing on its pointed end.

Neutral Equilibrium:

A body is in neutral equilibrium when on receiving a slight displacement it comes to rest in its new position, e.g. a cone resting on its curved surface, a ball rolling on horizontal surface.

43. Boiling takes place only at the boiling point temperature and above!

C

44. Real depth (R.d.) = ?
Apparent depth (A.d.) = 12m
Refractive index of water = 4/3

$$\text{Refractive index} = \frac{R.d.}{A.d.}$$

$$\text{Refractive index of water, } 4/3 = \frac{R.d.}{12.}$$

$$\text{R.d.} = 4/3 \times 12 = 16\text{m}$$

A

45.

$$\frac{E_S}{E_P} = \frac{N_S}{N_P}$$

E_S = voltage of secondary coil, E_P = voltage of primary coil, N_S = number of turns in secondary coil, N_P = number of turns in primary coil

$$\Rightarrow \quad E_S = \frac{E_P N_S}{N_P} = \frac{220 \times 400}{500} = 176V$$

C