



**ReEdited BY**

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## ***GRADE- 9 CHEMISTRY WORKSHEET***

***THIS WORK SHEET PREPARED FOR GRADE 9  
STUDENTS TO STUDY AT THEIR HOME  
BECAUSE OF THE IMPOSSIBILITY OF FACE TO  
FACE TEACHING-LEARNING PROCESS DUE TO  
CORONA VIRUS PANDEMIC DISEASE  
(COVID-19) IN 2020.***

***THE WORK SHEET CONTAINS SHORT NOTES,  
EXAMPLES, AND PRACTICE QUESTIONS.***

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## 4. CHEMICAL REACTIONS AND STOICHIOMETRY

Chemical reaction

- Is a chemical change.
- Change in which one or more new substances with new property is formed.
- Is process in which reacting species, called reactant, is converted to new substance, called product.
- Property of reactant is completely different from property of product.



Chemical change includes Change in original substances with:

- ❖ Composition/form or structure.
- ❖ Properties
- ❖ Energy of the reacting species involved in a chemical reaction.

1. Which of the following statement is correct?
    - I. Chemical reaction is the process in which appropriate starting material combine together to provide appropriate product.
    - II. Stoichiometry is the qualitative relationship between the reactants and products in a balanced chemical equation.
    - III. In order to calculate stoichiometric problems; one could check whether the law of conservation of mass and composition of substances with definite formula are properly stated.
    - IV. Stoichiometry is the study of quantitative aspects in a balanced chemical equation.

A. Only II      B. Only III      C. I, III and IV      D. II and IV only
  2. One of the following changes is example of a chemical change?
 

A. Evaporation of water.      C. Melting of ice.

B. The digestion of food.      D. Sublimation of  $\text{NH}_4\text{Cl}$ .
  3. Which of the following property is **not** express physical property of substances/matter?
 

A. Solubility of salts      C. Roasting of calcium carbonate in the presence of heat.

B. Melting of ice      D. Boiling of water
  4. Lead and chlorine form two compounds; for each 1 gram of lead one compound contains 3.81 gram of chlorine and another compound contain 5.70 gram of chlorine for each 1 gram of lead. This shows that:
 

A. The law of conservation of mass.      C. The law of gravitational force.

B. The law of constant composition.      D. The law of multiple proportions.
  5. Balance the following equation with the smallest whole number coefficients. Choose the answer that is the sum of the coefficients in the balanced equation. Do not forget coefficients of "one."
- $$\text{PtCl}_4 + \text{XeF}_2 \longrightarrow \text{PtF}_6 + \text{ClF} + \text{Xe}$$
- A. 16      B. 22      C. 24      D. 26      E. 32
6. Balance the following equation with the smallest whole number coefficients. Choose the answer that is the sum of the coefficients in the balanced equation. Do not forget coefficients of "one."
- $$\text{Cr}_2(\text{SO}_4)_3 + \text{RbOH} \longrightarrow \text{Cr}(\text{OH})_3 + \text{Rb}_2\text{SO}_4$$
- A. 10      B. 12      C. 13      D. 14      E. 15
7. One of the following is conserved in balancing chemical equation in each side of the equation?
 

A. Energy, mole and mass      C. Moles, coefficients and molecules

B. Mass, atoms and energy      D. Molecules, atoms and coefficients
  8. Balance the following equation using minimum integral coefficients:
 
$$\text{NH}_3 + \text{O}_2 \longrightarrow \text{NO}_2 + \text{H}_2\text{O}$$
 The stoichiometric coefficient for oxygen gas  $\text{O}_2$  is:
 

A. 1      B. 4      C. 3      D. 7      E. 5

9. When iron pyrite ( $\text{FeS}_2$ ) is heated in air, the process known as "roasting" forms sulfur dioxide and iron(III) oxide. When the equation for this process is completed and balanced, using the smallest whole number coefficients, what is the coefficient for " $\text{O}_2$ "?



- A. 2      B. 4      C. 7      D. 8      E. 11

## ENERGY CHANGE IN CHEMICAL REACTION

Almost all chemical reaction governed by energy change during the process. Energy may be added to/released to the surrounding depending on the type of chemical change.

Endothermic reaction

Exothermic reaction

Eno-means "into/added/absorbed"

Exo-means "released/given off".

Thermic means energy/heat

Energy added to the system from surrounding

-Energy released by the system to surrounding.

Reactant + Energy  $\rightarrow$  Product

Reactant  $\rightarrow$  Product + Energy

Heat content product is greater

-Heat content of reactant is greater

Change in energy have positive value

-Change in energy have negative value

$H = H_p - H_r$ ,  $\Delta H > 0$

$H = H_p - H_r$ ,  $\Delta H < 0$

$H_p > H_r$

$H_p < H_r$

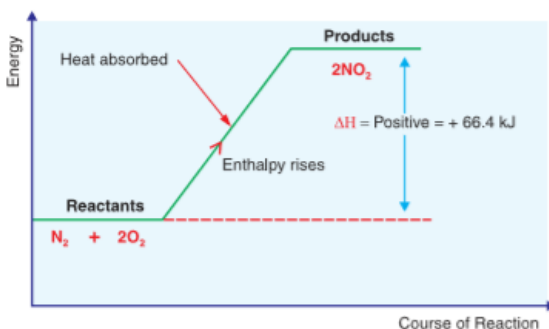
$\Delta H$  enthalpy of the reaction/heat of the reaction measured in kilo joule per mole (kJ/mol)

Ex:  $\text{N}_2(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g}); \Delta H = +66.4 \text{ kJ/mol}$

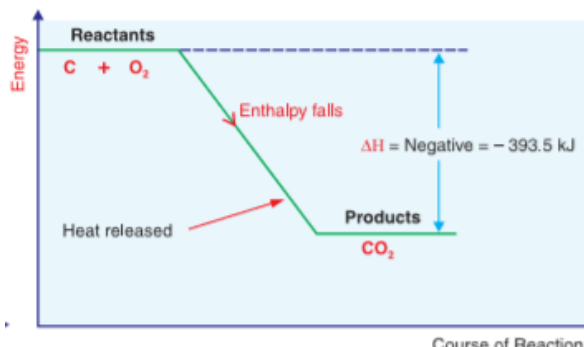
Example:  $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}); \Delta H = -393.5 \text{ kJ/mol}$

kJ/mol

Graphically



Energy diagram for an endothermic reaction.

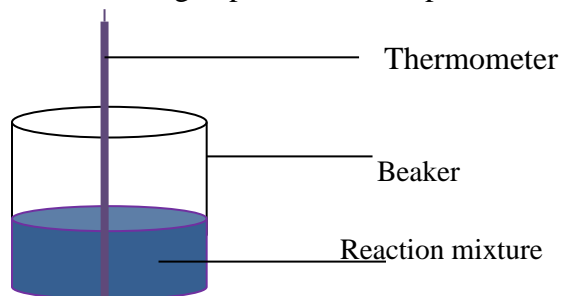


Energy diagram for an exothermic reaction.

10. An endothermic reaction is the reaction in which:

- A. Enthalpy change of the reaction has a negative value.  
B. Heat is absorbed to the system from the surrounding.  
C. Heat is given off by the system to the surrounding.  
D. The heat content of reactant is greater than that of heat of product.

11. Consider the following experimental setup:



If the thermometer reading was rising during the reaction, one can conclude from this experiment, the reaction is:

- A. An endothermic reaction      C. A combination reaction  
B. An exothermic reaction      D. A neutralization reaction

## TYPES OF CHEMICAL REACTIONS

Based on number of reactant involved and product formed; chemical reaction can be classified as

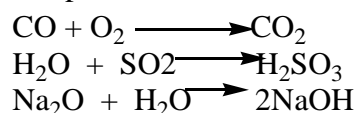
1. Combination reaction
2. Decomposition reaction
3. Single displacement reaction
4. Double displacement reaction/metathesis reaction.

### 1. Combination/synthesis reaction

Two or more reactants combined together to form a single product

$A + B \longrightarrow AB$  Where A & B may be element or be a compound and AB (product) always a compound

Example



### 2. Decomposition reaction

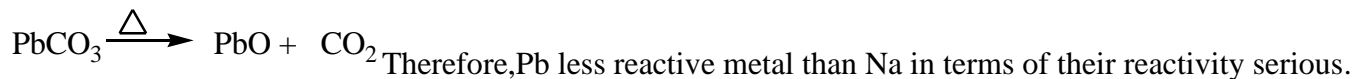
Decomposition Reaction is that involves the breaking down of a single compound into two or more elements or simpler compound. It can be carried out by the presence of heat, light, electricity or a catalyst.

$AB \longrightarrow A + B$  Where the reactant AB must be a compound and the products A and B could be elements or compounds.

### Decomposition of carbonates

Decomposition of metal carbonates related to position of metal in their reactivity series. This means, thermal stability of metal carbonates is depend on position of the metal in the reactivity series. The more reactive the metal is, the more difficult is it to decompose its compound. Therefore, Na & K carbonates are not affected by heat.

Example  $\text{Na}_2\text{CO}_3 \xrightarrow{\Delta}$  No reaction  
While



12. Which of the following reaction represents decomposition reaction?

- $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \longrightarrow 2\text{NH}_3(\text{g})$
- $2\text{HBr} + \text{Cl}_2 \longrightarrow 2\text{HCl} + \text{Br}_2$
- $\text{Ba}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \longrightarrow \text{BaSO}_4 + 2\text{NaNO}_3$
- $\text{Pb}(\text{NO}_3)_2 \xrightarrow{\Delta} \text{PbO} + \text{NO}_2 + \text{O}_2$

SOLUTION: A-Is combination /synthesis reaction

B. Single displacement reaction, more active displaces less active element.

C. Double displacement reaction/non redox reaction because only exchange of ion change of ions be takes place during double displacement reaction.

D. decomposition reaction

Therefore, D is the correct answer.

13. All of the following decomposition of metallic nitrate yields the same product, EXCEPT

- $\text{Pb}(\text{NO}_3)_2$
- $\text{Pb}(\text{NO}_3)_2$
- $\text{LiNO}_3$
- $\text{NaNO}_3$

Decomposition of lithium nitrate, transitional metal, group IIA, most metallic nitrate decompose by heat to yield metallic oxide, nitrogen dioxide and oxygen except for the decomposition of Na & K nitrate decomposition which yields nitrite salt and oxygen.

## 1. Single replacement reaction

A reaction in which one element displaces another element from its compound is known as single displacement or replacement reaction. Such a reaction is represented by the following two general forms.

$A + BC \longrightarrow AC + B$  If A is a metal, it will displace B to form AC, provided that A is a more active metal than B.

$A + BC \longrightarrow BA + C$  If A is a non-metal, it will displace C to form BA, provided A is a more active non-metal than C.

Example

1.  $Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$
2.  $Cu + Zn(NO_3)_2 \longrightarrow$  no reaction
3.  $F_2 + CaCl_2 \longrightarrow CaF_2 + Cl_2$
4.  $Br_2 + NaCl \longrightarrow$  no reaction

In general, a more reactive element displaces a less reactive element from a compound.

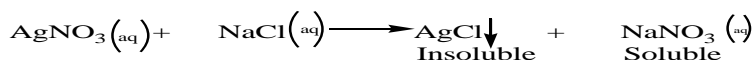
## 2. Double displacement reaction

Type a reaction in which two compounds react together to form two new compounds by exchange of the positive and negative ions of each reactant. Such a reaction is also known as double replacement reaction or metathesis.

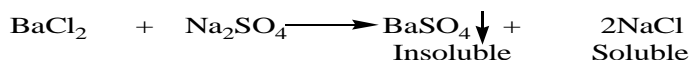
General form of equation:  $AB + CD \longrightarrow AD + CB$

### Examples

The two soluble compounds  $AgNO_3$  and  $NaCl$  react to produce an insoluble precipitate of  $AgCl$  and a soluble  $NaNO_3$  solution.



When aqueous solutions of  $BaCl_2$  and  $Na_2SO_4$  react, a precipitate of  $BaSO_4$  is formed.



## STOICHIOMETRY

**Definition:** is the quantitative study of chemical reaction among reactant and product.

Its calculation based on composition of substances and conservation of mass.

Stoichiometric problems are: mass-mass, mass- volume, mass- mole, mole-mole, mole-volume and volume-volume problem be solved based on the given information from the chemical reactions.

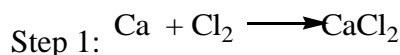
Examples: read from textbook.

14. In order to carry out mass-mass stoichiometric calculation one should do the following, EXCEPT

- A. Write balanced chemical equation appropriately with appropriate chemical formulae.
- B. Write the mass given just above atom/molecule or compound in the reaction equation.
- C. Write 'X' for unknown mass we will go calculate just above that formula correctly and set up the proportion to solve for unknown mass of substance.
- D. Write the molecular weight of substances in which the mass is given and that of substances in which we are going to calculate mass just above the formula in gram per moles.

15. Calculate the mass of  $\text{CaCl}_2$  formed when 5 moles of chlorine reacts with calcium metal.

Solution:



Step 2: moles of  $\text{Cl}_2 = 71 \text{ g/mol}$



Given n of  $\text{Cl}_2 = 5 \text{ mol}$

M of  $\text{CaCl}_2 = 111 \text{ g/mol}$

Calculate mass of  $\text{CaCl}_2$

Step 4: calculate for the required one from the given information by setting up proportion.

$$\frac{5 \text{ mol}}{71 \text{ g/mol}} = \frac{x}{111 \text{ g/mol}}$$

$$|71x = 111 \times 5 \text{ mol}| \text{ of } \text{CaCl}_2$$

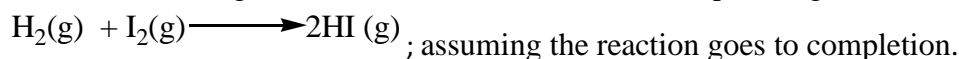
$$x = \frac{555 \text{ mol}}{71} \text{ CaCl}_2 \text{ is formed.}$$

$x = 7.81 \text{ mol}$   $\text{CaCl}_2$  is formed. Therefore, converting the obtained mole into mass by using its molar mass.

Mass of  $\text{CaCl}_2$  formed  $= 7.81 \text{ mol} \times 111 \text{ g/mol}$

Mass of  $\text{CaCl}_2$  formed,  $x = 867.67 \text{ g}$  of  $\text{CaCl}_2$  is formed.

16. Which of the following statement is true for the chemical equation given below:



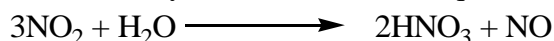
A. One mole of  $\text{I}_2$  reacts with three molecules of  $\text{H}_2$  to provide two moles of HI.

B. Two grams of  $\text{H}_2$  combined with one mole of  $\text{I}_2$  to provide  $256.0 \text{ g/mol}$  of HI.

C. One mole of  $\text{H}_2$  reacts with three moles of  $\text{I}_2$  to provide one mole of HI.

D. One molecule of  $\text{I}_2$  requires three atoms of hydrogen for complete reaction.

17. How many moles of  $\text{H}_2\text{O}$  are required to produce 4.5 moles of  $\text{HNO}_3$  according to the following reaction?



**Answer 2.25 mole of water is needed to produce 4.5 mole  $\text{HNO}_3$**

18. How many grams of oxygen is formed when 3 moles of potassium chlorate is decomposed according to the

reaction equation i.e;  $\text{KClO}_3(\text{s}) \xrightarrow{\Delta} \text{KCl}(\text{s}) + \text{O}_2(\text{g})$ ? [Use A. wt. (g/mol) K = 39, Cl = 35.5 and O = 16].

A. 140.00g      B. 440.00g      C. 144.00g      D. 441.00g

## Limiting and excess reagents

When all the reactants are completely consumed equally in a given a chemical reaction, such reactants are said to be in stoichiometric proportions. But, practically these types of chemical reactions do not always occur because of excess or limited reactant.

**Limiting reagent:** Reactant/reagent that determines the product formed during the chemical reaction.

Reactant totally consumed over the reaction.

**Excess reactant/reagent:** reactant/reagent that left over the reaction being unconsumed over the reaction.

Reactants that do not determine the product formed during the process.

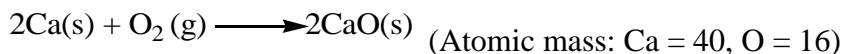
19. If, in the reaction  $\text{W} + \text{X} \rightarrow \text{Y} + \text{Z}$ , the quantity of X is insufficient to react with all of W,

A. W is the limiting reactant.      C. the reaction is in stoichiometric proportions.

B. X is the limiting reactant.      D. It is difficult to determine



20.If 3 moles of Calcium are reacted with 2moles of Oxygen according to the following equation.

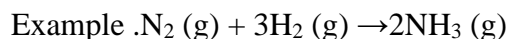


Which of the following is **NOT** true about the above reaction?

- A. 48gm of Oxygen is used as reacted amount      C. 168gm of CaO is produced  
B. 16gm of excess reactant are left over      D. 224gm of CaO is produced.

## Percent yield

Although we can write perfectly balanced chemical equation to represent perfect reactions, the reaction themselves are often not perfect. A reaction does not always produce the quantity of product that the balanced equation seems to guarantee. This happens not because the equation is wrong but because reactions in the real world seldom.



In the manufacturing of ammonia, it is nearly impossible to produce 2 mol (34g) of  $\text{NH}_3$  from the simple reaction of 1 mol (28g) of  $\text{N}_2$  and 3mol (6 g) of  $\text{H}_2$  because some of ammonia molecules begin breaking down into  $\text{N}_2$  &  $\text{H}_2$  molecules as soon as they are formed.

✓ There are several reasons that real world reaction does not produce products at a yield of 100%. some are simple mechanical reasons .such as :

- ✚ Reactants or products are leak out, especially when they are gases.
- ✚ Reactants are not 100% pure.
- ✚ Some products are lost when it is purified.

✓ There are also some chemical reasons including :

- The products decompose back into reactants (as with ammonia process).
- The product reacts to form different substances.
- Some of the reactants react in ways other than the one shown in equation .thus are called side reactions.
- The reaction may occur very slowly .this especially true for reaction involving organic substances.

❖ Chemists are very concerned with the yields of reaction because they must find ways to carry out reactions economically and on a large scale. If the yields of reaction are too small, the product may not be competitive in the market place. If a reaction has only 50% yield, it produces only 50% of the amount of product that it's theoretically should.

21. Actual yield must be determined by:

- A. Estimated value.    B. Calculated from balanced equation.    C. Experimental value.    D. Theoretical yield.

22. Iron reacts with copper (II) sulfate to form iron (II) sulfate and copper (Cu) according to the following equation:  $\text{Fe(s)} + \text{CuSO}_4(\text{aq}) \rightarrow \text{FeSO}_4(\text{aq}) + \text{Cu(s)}$

A student calculates the amount of each reactant needed to produce 14.0 g of iron (II) sulfate. When she measures the mass of iron (II) sulfate actually produced in the lab, it is found to be 12g. What is the percent yield?

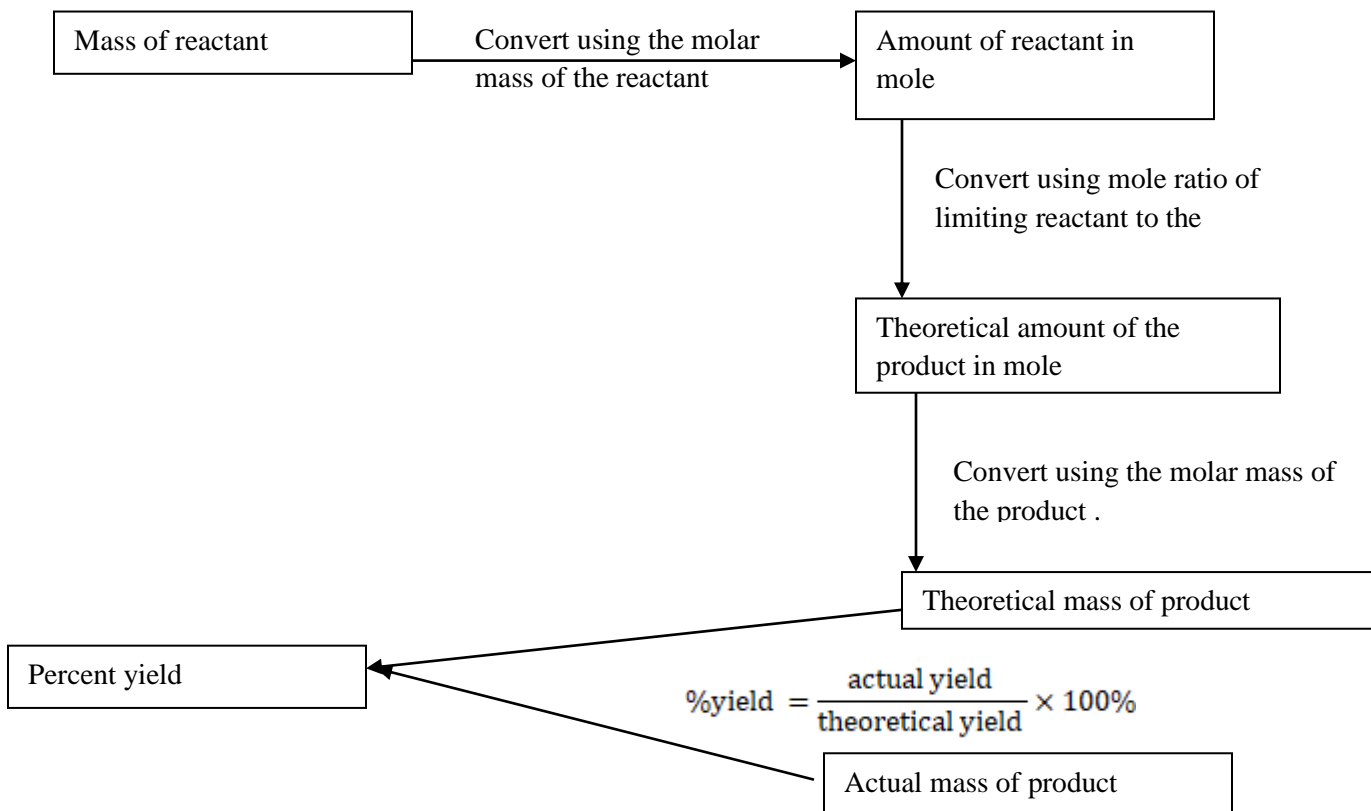
- A. 85.7    B. 58.3    C. 25    D. 8.97

23. What is the correct mathematical expression for the relationship among percentage yield, actual yield, and theoretical yield?

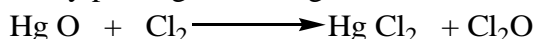
- A.  $\text{Actual yield} = \frac{\text{percentage yield}}{\text{theoretical yield}} \times 100$       C.  $\text{Percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$   
B.  $\text{Percentage yield} = \frac{\text{theoretical yield}}{\text{actual yield}} \times 100$       D.  $\text{Theoretical yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$



❖General plan for solving percent yield problems.



24. Dichlorine monoxide,  $\text{Cl}_2\text{O}$  is sometimes used as a powerful chlorinating agent in research. It can be produced by passing chlorine gas over heated mercury (II) oxide according to the following equation.



What is the percent yield, if the quantity of reactants is sufficient to produce 0.86g of  $\text{Cl}_2\text{O}$  but only 0.71g is obtained?

Given theoretical yield = 0.86g

Actual yield = 0.71g

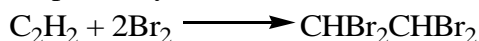
Required %yield = ?

Solution % yield =  $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

$$= \frac{0.71\text{g}}{0.86\text{g}} \times 100\%$$

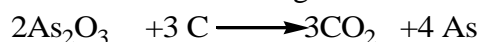
$$= 0.83 \times 100\% = 83\%$$

25. If 72 g of acetylene,  $\text{C}_2\text{H}_2$  react with excess bromine and 729 g of the product is recovered, what is the percent yield of the reaction? (At. Wt C=12, H =1, Br=80)



**Answer.** %yield = 81.9%

26. In the commercial production of the element arsenic (III) oxide is heated with carbon, which reduces the oxide to the metal according to the following equation:



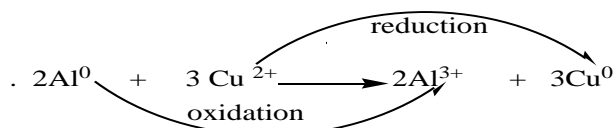
- A.If 8.87g of  $\text{As}_2\text{O}_3$  is used in the reaction and 5.33g of As is produced, what is the percent yield of the reaction?
- B.If 67g of carbon is used up in different reaction and 425g of As is produced, calculate the percent yield of the reaction.(At. Wt. C=12 ,O=16 ,As 75)

**Answer.** A. 79.3%yield

B.76% yield

## OXIDATION AND REDUCTION REACTIONS

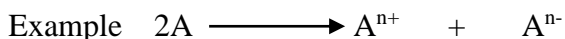
Redox reactions are comprised of two parts, a reduced half and an oxidized half, that always occur together. The reduced half gains electrons and its oxidation number decreases but its number of electron increases. The oxidized half loses electrons and its oxidation number increases while its total number of electron decreases. Example; 1.



Al –is oxidized (its oxidation number goes from 0 to +3);

$\text{Cu}^{2+}$ –is reduced (its oxidation number goes from +2 to 0).therefore, the reaction is a redox reaction because both oxidation and reduction reaction happens at the same time.

**Disproportion redox reaction:** reaction in which single substances/atoms can undergo both oxidation and reduction reaction



Where n is number of electron transferred. Disproportionate reaction does not begin with neutral molecules, and can involve more than two species with differing oxidation state. (But rarely)

Disproportionate reactions have practical significances in everyday life, including the reaction of hydrogen peroxide,  $\text{H}_2\text{O}_2$  poured over a catalyst. This decomposition reaction of  $\text{H}_2\text{O}_2$ , which produces oxygen and water .Oxygen that present in all parts of the chemical reaction undergo both oxidized and reduced .the reaction as follows:



on reactant side ,H has oxidation state of +1 and oxygen has oxidation state of -1,which changes to -2 for product  $\text{H}_2\text{O}$  (oxygen is reduced )and zero(0) in the product  $\text{O}_2$  (oxygen is oxidized).

27.Identify disproportionate redox reaction from the given chemical reactions.

- A.  $\text{CO}_3^{2-} + 2\text{H}^+ \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$
- B.  $\text{NO}_2 + \text{H}_2\text{O} \longrightarrow \text{HNO}_3 + \text{NO}$
- C.  $\text{H}_2\text{SO}_4 + \text{KOH} \longrightarrow \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$
- D.  $\text{Ba}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \longrightarrow \text{BaSO}_4 + 2\text{NaNO}_3$

**Solution:** choice A, C, D, is non-redox reaction at all .Because there is no loss and gain of electron during the reaction. Or, there is no change in its oxidation state of every element involved in the reaction .such reaction is known as non -redox reaction.

In  $\text{NO}_2 + \text{H}_2\text{O} \longrightarrow \text{HNO}_3 + \text{NO}$ , the oxidation state of nitrogen in  $\text{NO}_2$  is +4;  $\text{HNO}_3$  is +5 and in  $\text{NO}$  are +2 from its compound .Because the summation of all constituent atoms in compound is

equal to zero. **Disproportionate redox reaction** is a type of redox reaction in which a single element undergo both oxidation and reduction reaction within a single chemical reaction.

28. Arrange the following species in order of increasing oxidation number of sulfur atom in its compound/radicals.  $S_8$ ,  $H_2S$ ,  $S_2O_8^{2-}$ ,  $H_2SO_4$ ,  $SO_3^{2-}$

SOLUTION: the oxidation state of sulfur in the above molecules, radicals /compound is:

$S_8^0$ ,	$H^{+1}_2S^x$	$(S^x_2O^{2-}_8)^{2-}$	$H^{+1}_2S^xO_4^{-2}$	$(S^xO^{2-}_3)^{2-}$
0	$2(+1) + x = 0$	$2X + 8(-2) = -2$	$2(+1) + X + 4(-2) = 0$	$1(X) + 3(-2) = -2$
	$2 + x = 0$	$2X - 16 = -2$	$2 + X + (-8) = 0$	$X - 6 = -2$
	$X = -2$	$2X = -2 + 16$	$X - 6 = 0$	$X = -2 + 6$
		$2x = 14$	$X = 6$	$X = 4$
		$X = 7$		

Therefore, the oxidation state of sulfur is 0, -2, 7, 6 & 4. when this arranged according to increasing order of its oxidation state:  $H_2S$ ,  $S_8$ ,  $S_2O_3^{2-}$ ,  $H_2SO_4$ ,  $S_2O_8^{2-}$  (-2, 0, 4, 6 & 7)

**Oxidation** mean increase in its oxidation number (substances oxidized) while its number of electron decreases.

29. Hydrogen has an oxidation number of -1 in  
 A.  $H_2$       B.  $NaH$       C.  $H_2O$       D.  $KOH$
30. Oxidation number of oxygen in  $OF_2$  is  
 A. +1      B. -1      C. +2      D. -2
31. Which of the following is the definition of oxidation  
 A. gain of electrons      B. loss of electrons      C. addition of  $H_2$       D. removal of  $O_2$
32. Which element acts as a reducing agent in the reaction  $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$   
 A. Zn      B. H      C. S      D. O
33. When iron is manufactured from hematite, Iron (III) oxide reacts with carbon monoxide to produce iron and carbon dioxides.  $Fe_2O_3 + CO \rightarrow Fe + CO_2$ . Is this a redox reaction?  
 A. yes  $Fe_2O_3$  is a oxidizing agent, CO is the reducing agent  
 B. yes  $Fe_2O_3$  is a reducing agent, CO is oxidizing agent  
 C. No, because there is no change in oxidation state  
 D. No, because there is no color change

## Oxidizing and reducing agent

Oxidizing agent  
 substances that :

Reducing agent

- |  |  |
|--|--|
| ● cause another substances to be oxidized but itself reduced | ● cause another substances to be reduced but itself oxidized |
| ● gain electron/electron acceptor                            | ● lose electron/electron supplier                            |
| ● its oxidation number decreases                             | ● its oxidation number increases.                            |
| ● its number of electron increases.                          | ● its number of electron decreases.                          |

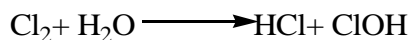
34. What happens to a reducing agent in an oxidation –reduction reaction?  
 A. It self reduced as it loses electrons.      C. It self oxidized as it loses electrons.  
 B. It self reduced as it gains electrons.      D. It self oxidized as it gains electrons.
35. Which of the following is not oxidizing agent?

+7	+6	+7	+2
A. $KMnO_4$	B. $K_2Cr_2O_7$	C. $NaClO_4$	D. CO

36. When metal atoms form a cation:

- A. It is oxidized  
B. It is reduced  
C. It is neither oxidized nor reduced  
D. It acts as an oxidizing agent

37. What happens to chlorine in the reaction below?



- A. It has been oxidized only  
B. It has been reduced only  
C. It has been oxidized as well as reduced  
D. It has been neither oxidized nor reduced

38. In which of the following Cr has an oxidation number of +3?

- A.  $\text{Cr}_2\text{O}_8^{2-}$   
B.  $\text{CrO}_2^{2-}$   
C.  $\text{Cr}_2\text{O}_4^{2-}$   
D.  $\text{Cr}_2\text{O}_4$

39. Which of the following represents a redox reaction?

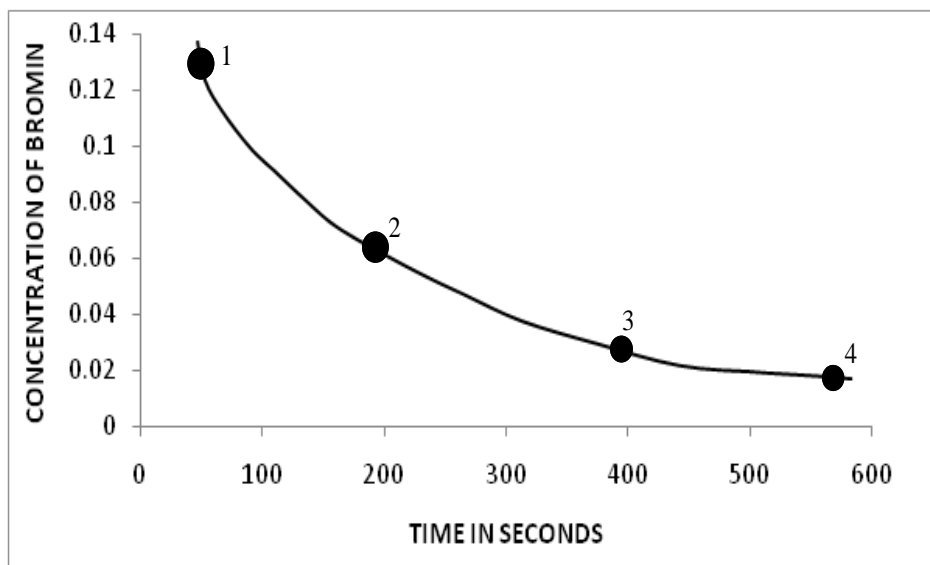
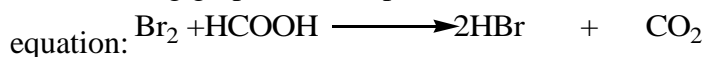
- A.  $\text{H}_2\text{CO}_3 \longrightarrow \text{H}_2\text{O} + \text{CO}_2$   
B.  $\text{CuS} + \text{H}_2 \longrightarrow \text{H}_2\text{S} + \text{Cu}$   
C.  $\text{AgNO}_3 + \text{NaCl} \longrightarrow \text{AgCl} + \text{NaNO}_3$   
D.  $2\text{HCl} + \text{Na}_2\text{SO}_3 \longrightarrow 2\text{NaCl} + \text{H}_2\text{SO}_3$

40. Which one of the following is **true** about **reducing agent**?

- A. It reduces others by oxidizing itself  
B. It reduces others but is not necessarily oxidized or reduced  
C. It oxidizes others by reducing itself  
D. It oxidizes others but is not necessarily oxidized or reduced

## RATES OF CHEMICAL REACTIONS AND CHEMICAL EQUILIBRIUM

41. The following graphs show a plot of concentration of bromine versus time represented by the reaction



At which point on the plot the reaction will occur at the fastest rate?

- A. 1  
B. 2  
C. 3  
D. 4

**Solution:** At the beginning of the reaction, the rate at which reactants are converted to product is high because concentration affects the rate of chemical reaction, as concentration increases, more number of reacting species collide together. As concentration decreases, the rate of reaction also decreases or concentration is directly proportional to the rate of reaction. As time increases, the rate of reaction decreases or rate is inversely proportional to time.

$$\text{rate} \propto \text{concentration}$$

$$\text{rate} \propto \frac{1}{\text{time}}$$

Generally, the rate of a reaction can be obtained by measuring either one of the above changes in properties of substances and consequently relating to changes in their concentrations during the course of the reaction.

$$\text{Rate of reaction} = \frac{\text{Change in concentration of substance}}{\text{Change in time}} = \frac{\Delta C}{\Delta t}$$

Note that the rate of a reaction is the slope of the tangent to the curve at any particular time.

Graphically:

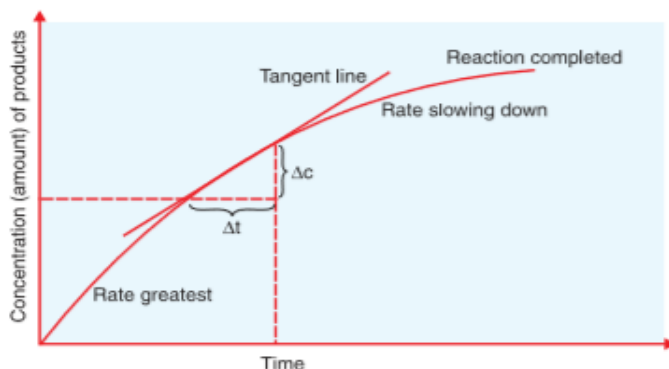


Figure. The change in concentration of product with time.

42. For a chemical reaction to take place, one of the following preconditions is **not** necessary important
- Reactant particle must have sufficient energy of collision
  - Reactant particles should have come in contact to one another.
  - Reactant particle should have similar size
  - Reactant particle should have proper orientation in space
43. A reaction which proceeds in both forward and backward direction is called:
- Thermo chemical reaction
  - Reversible reaction
  - Irreversible reaction
  - Physical reaction
44. Rate of reaction is defined as
- Decrease in the concentration of a reactant
  - Increase in the concentration of a product
  - Change in the concentration of any one of the reactants or products per unit time.
  - All the above three are correct
45. Which factor has negligible effect on equilibrium reactions involving solids and liquids?
- Pressure
  - concentration
  - temperature
  - catalyst
46. In which of the following reactions does pressure have no effect on the equilibrium?
- $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
  - $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
  - $2\text{H}_2\text{O}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$
  - $\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g})$
47. Which of the following does not shift the position of the equilibrium?
- Concentration
  - Pressure
  - Catalyst
  - Temperature
48. Given that:  $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ . Which of the following statements is wrong?
- Removing certain  $[\text{CaO}]$  will shift the equilibrium to the right.
  - Adding certain  $[\text{CaCO}_3]$  will have no impact on the equilibrium position
  - The  $K_c$  expression for the reaction is equal to  $\frac{1}{[\text{CO}_2]}$ .
  - Removing certain  $[\text{CaO}]$  will shift the equilibrium to the left.

**NB** when you are going to calculate the equilibrium concentration do not include concentration of liquid and solid. Because concentration of liquid and solid be considered as a unity (one).

$$K_C = \frac{\text{conc.Product}}{\text{conc.reactant}}$$

49. For a reaction to shift towards the product direction, which of the following condition holds true?

- A.  $Q_c < K_c$       B.  $Q_c > K_c$       C.  $Q_c = K_c$       D.  $Q_c = K_c = 0$

50. For the equation  $2C(s) + O_2(g) \leftrightarrow 2CO(g)$ , the expression for  $K_c$  is:

- A.  $\frac{2[CO]}{2[C][O_2]}$       B.  $\frac{[CO]^2}{[C]^2[O_2]}$       C.  $\frac{[CO]^2}{[O_2]}$       D.  $\frac{2[CO]}{[O_2]}$

51. The rate of reaction is:

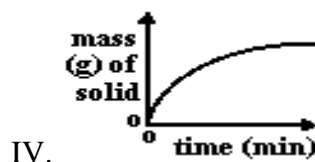
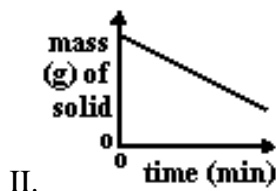
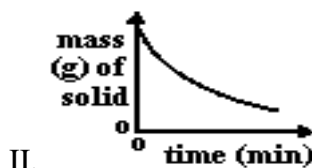
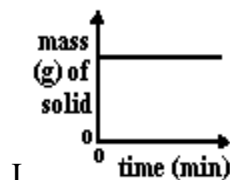
- A. Increase with time      C. Decrease with time  
B. Independent to time      D. Not change with time

52. The minimum amount of energy required for the reacting molecules to undergo reaction is called:

- A. Potential energy      C. Internal energy  
B. Activation energy      D. kinetic energy

53. Limestone chips were reacted with acid in a beaker placed on one pan electric balance. The mass of the reacting mixture was measured at regular time intervals.

Which graph would you expect the results to be like?



- A. Graph I      B. Graph II      C. Graph IV      D. Graph III

54. As an element is oxidized, its oxidation number

- A. increases as electrons are lost      C. decreases as electrons are lost  
B. increases as electrons are gained      D. decreases as electrons are gained

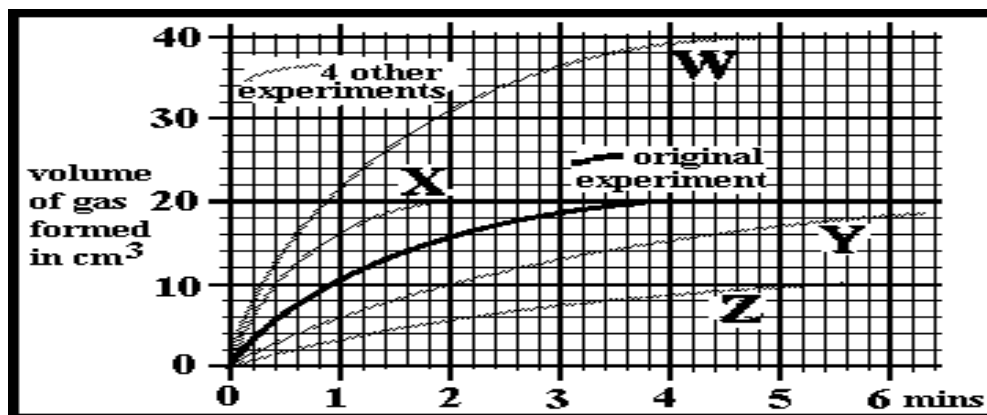
55. For the  $SO_2(g) + O_2(g) \rightleftharpoons SO_3(g) + \text{Heat}$ , If the temperature is increased the amount of  $SO_3(g)$  produced will be:

- A. Increase.      B. decrease.      C. remains the same.      D. no effect

56. Which of the following equilibrium would be affected by volume changes at constant temperature?

- I.  $C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$   
II.  $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(l)$   
III.  $SO_3(g) + NO(g) \rightleftharpoons NO_2(g) + SO_2(g)$

- A. III only      B. I and II only      C. I and III only      D. II and III only



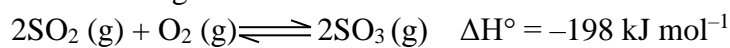
57. An experiment was carried out at a temperature of 25°C by dissolving 0.2g of small limestone granules into 30cm<sup>3</sup> of hydrochloric acid. The acid concentration was 1.0 mol/dm<sup>3</sup> and in excess so all the limestone dissolved. The reaction was followed by measuring the volume of carbon dioxide given off over a period of 6 minutes. A 2<sup>nd</sup> experiment was done in an identical manner but using 0.4g of the same lime stone granules. Which of the graphs W, X, Y or Z might you expect for the results?

- A. Graph line W      B. graph line X      C. graph line Y      D. graph line Z

58. For irreversible chemical reactions, the rate will be affected by changes in all of these factors except:

- A. Temperature.      C. Concentration of reactants.  
B. Presence of a catalyst.      D. Concentration of products.

59. Based on the given reaction.

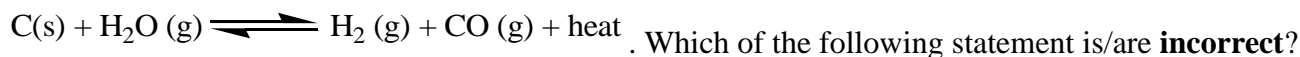


The equilibrium constant for this reaction at 830 °C is 0.25atm<sup>-1</sup>

Which one of the following is the correct expression for the equilibrium constant?

- A.  $K_c = \frac{[\text{SO}_3]}{[\text{SO}_2][\text{O}_2]}$       C.  $K_c = \frac{[\text{SO}_3]}{[\text{SO}_2][\text{O}_2]}$   
B.  $K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$       D.  $K_c = \frac{[\text{SO}_2]^2[\text{O}_2]}{[\text{SO}_3]^2}$

60. Assume that the following endothermic chemical reaction is at equilibrium:

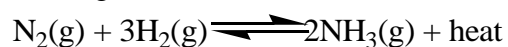


. Which of the following statement is/are **incorrect**?

- I. Increasing concentration of H<sub>2</sub>O(g) will cause the reaction to proceed in the forward direction, increasing the concentration equilibrium of CO(g)  
II. Increasing temperature will cause the reaction to proceed in the forward direction, increasing the concentration equilibrium of CO(g)  
III. Increasing the amount of C(s) will cause the reaction to proceed in the forward direction, increasing the concentration equilibrium of CO(g)

- A. I only      B. II only      C. II and III only      D. I and II only

61. Which change would favors the net reverse reaction for the system,



- A. A decrease in the concentration of ammonia      C. a decrease in the temperature  
B. A decrease in the concentration of nitrogen      D. a decrease in the volume

62. Which change will increase the amount of SO<sub>3</sub>?  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) + \text{heat}$

- A. Decrease the concentration of O<sub>2</sub>(g).      C. Increase the temperature of the system.  
B. Increase the pressure on the system.      D. Introduce a catalyst.



63. How does a catalyst speed up a chemical reaction? By

- A. Decreasing the heat of reaction.
- B. Providing an alternative pathway with lower activation energy.
- C. Increasing the heat of reaction.
- D. raising the activation energy

64. When the concentrations of reactant molecules are increased, the rate of reaction increases.

The best explanation for this phenomenon is that as the reactant concentration increases,

- A. The average kinetic energy of molecules increases.
- B. The frequency of molecular collisions increases.
- C. The rate constant increases.
- D. The activation energy increases.

**Activation energy:** is minimum amount of energy needed to start a chemical reaction, because collision only is not a sufficient condition to cause a reaction.

65.  $\text{C}_6\text{H}_6 + \text{Br}_2 \xrightarrow{\text{catalyst}} \text{C}_6\text{H}_5\text{Br} + \text{HBr}$  Which of the following changes will cause an increase in the rate of the above reaction?

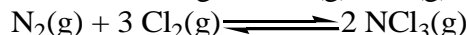
- A. increasing the concentration of  $\text{Br}_2$
- C. decreasing the concentration of  $\text{C}_6\text{H}_6$
- B. increasing the concentration of  $\text{HBr}$
- D. decreasing the temperature

**Catalyst:** substances that speed up the rate of chemical reaction without altering its composition and properties. There are two types of catalyst. These are:

➤ **Inhibitors:** catalyst that speed up the rate of reverse/backward reaction (negative catalyst).

➤ **Prohibitors:** catalyst that speed up the forward reaction (positive catalyst).

66. A collection of gases  $\text{N}_2(\text{g})$ ,  $\text{Cl}_2(\text{g})$  and  $\text{NCl}_3(\text{g})$  are in equilibrium in a reaction vessel.



Suddenly the vessel size is compressed to half its volume. What will happen?

- A. The system will no longer be in equilibrium and more products will form as equilibrium is restored.
- B. The system will no longer be in equilibrium and more reactants will form as equilibrium is restored.
- C. Nothing will change. The system is remaining at equilibrium.
- D. It is difficult to estimate its effect.

67. Which of the following factors only affects the rate of heterogeneous reactions?

- A. Catalyst
- B. Temperature
- C. surface area
- D. concentration

**Surface area:** the contact area the reacting species.

➤ The higher contact area of the reacting species is the faster is its rate of reaction. Because more contact results in more collision for heterogeneous reactant.

➤ Heterogeneous reactants are reactants that exist in different phase/state.

Example: liquid to solid, solid to gas, gas to liquid reactions.

68. Three of the following factors can affect the forward **rate** of a chemical reaction. Which one cannot affect this rate?

- A. Temperature
- B. Concentration of reactants of the forward reaction
- C. Removal of some of the products of the forward reaction
- D. Presence of a catalyst

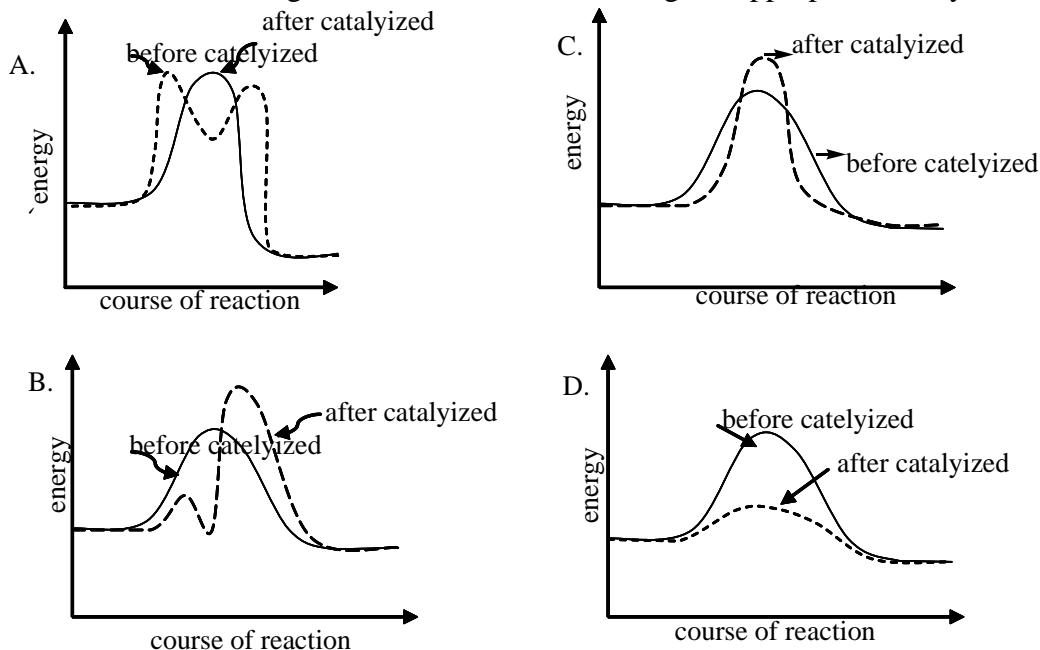
69. What is the relationship between equilibrium constant ( $K_c$ ) & the rate constant for the forward ( $K_f$ ) and reverse reaction ( $K_b$ )?

- A.  $K_c = K_f K_r$
- B.  $K_c = \frac{K_r}{K_f}$
- C.  $K_c = \frac{K_f}{K_r}$
- D.  $K_c = \frac{1}{K_f K_r}$

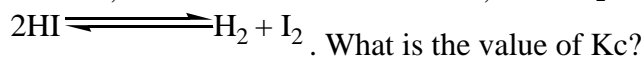
70. Which factor explains why potassium generally reacts faster than sodium?

- A. Surface area
- B. Temperature
- C. Concentration
- D. Nature of reactants

71. Which reaction diagram shows the effect of using the appropriate catalyst in a chemical reaction?



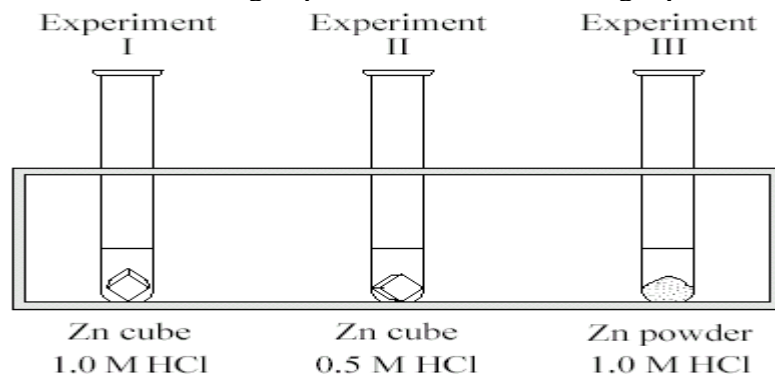
72. At 22 °C, a 2L flask contains 8mol HI, 8mol H<sub>2</sub> & 4 mole I<sub>2</sub> in equilibrium.



. What is the value of K<sub>c</sub>?

- A.  $\frac{1}{2}$       B. 2      C. 3      D. 4

73. Consider the following experiments, each involving equal masses of zinc and 10.0 ml of acid:



The rate of reaction in order from fastest to slowest is

- A. I > II > III      B. II > I > III      C. III > I > II      D. III > II > I

74. Which statement(s) is/are true regarding the reaction below?



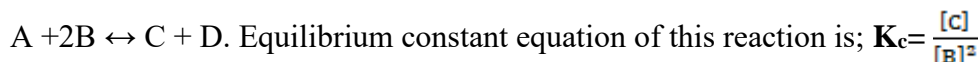
- I. An increase in pressure will increase the rate and shift the equilibrium to the right.  
 II. An increase in temperature will increase the rate and shift the equilibrium to the right.  
 III. A catalyst will increase the rate and shift the equilibrium to the right.

- A. I & II      B. I, II & III      C. I & III      D. II & III

75. How does activation energy cause a chemical reaction to occur? Initially by

- A. Forming a new bond  
B. Minimizing the number of collisions  
C. Breaking an original bond  
D. Hindering the reverse reaction.

76. Following reaction includes matters in solid and gas phases.



Which ones of the following statements are true for this reaction?

- I. A and D are solids  
II. Increasing pressure shifts equilibrium to the right  
III. Adding A increases D production  
A. I, II & III  
B. I & III  
C. II & III  
D. I & II

77. Consider the following reactions:

- I.  $N_2(g) + O_2(g) \rightarrow 2NO(g)$   
II.  $Mg(s) + O_2(g) \rightarrow 2MgO(s)$   
III.  $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

Increasing the surface area will increase the reaction rate in

- A. II only  
B. I and III only  
C. II and III only  
D. I, II, and III

78. Ethanol can be manufactured by the reaction between ethene and water.

This is represented by the equation  $C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$   $\Delta H = -46 \text{ kJ mol}^{-1}$

Which conditions would produce the highest percentage yield of ethanol at equilibrium?

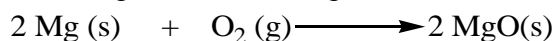
- A. Low pressure and low temperature  
B. High pressure and low temperature  
C. Low pressure and high temperature  
D. High pressure and high temperature

79. Which of the following is **not** true about the factors that affect rate of chemical reaction to yield high

Product is:

- A. Increasing temperature by blowing of more air into the burning wood.  
B. Increasing concentration of product and decreasing the concentration of reactant  
C. Increasing surface area of the reacting species  
D. Adding catalyst

80. If 2 moles of magnesium is heated in 3 moles of oxygen. How many moles of excess reactant left unreacted according to the following reaction?



- A. 1.5 moles of Mg  
B. 1 mole of  $O_2$   
C. 1 mole of Mg  
D. 2 mole of  $O_2$

81. Which of the following **true** about characteristics of a reaction at equilibrium?

- A. Concentration of the reactant(s) and product(s) are different  
B. Rate of forward and reverse reactions is equal  
C. Appearance of the reactant(s) and disappearance of the product(s) are equal  
D. If it's exothermic in one direction, it is also exothermic in the reverse direction

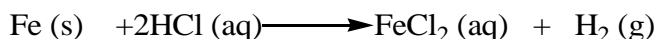
**Equilibrium reaction** means reaction at which the forward and reverse reaction takes place at equal rate.

82. The statement "If a condition is changed, the position of equilibrium will shift in a manner to oppose the change and restore the original equilibrium condition." Is stated by:

- A. Avogadro's principles  
B. Le Chatelier's principle  
C. The law of mass action  
D. The law of constant composition

**Le Chatelier states** that if a stress is applied to a system in equilibrium, the system will respond in such a way to counteract the stress. The stress could be change in temperature, concentration or pressure.

83. Given the balanced equation representing the reaction:



This reaction occurs more quickly when powdered iron is used instead of a piece of iron of the same mass because the powdered iron

- A. Act as a better catalyst than the piece of iron
- B. Has a greater surface area than the piece of iron
- C. Absorb less energy than the piece of iron
- D. Is more metallic than piece of iron

84. Under what conditions of temperature and pressure carbon dioxide gas does behaves most likely an ideal gas?

- A. High temperature and low pressure
- B. High temperature and high pressure
- C. Low temperature and low pressure
- D. Low temperature and high pressure

85. Why does reaction rate increases as the concentration increases?

- A. There are more particles so there is more collision
- B. The surface area increased so there is more collision.
- C. Due to particles having more energy so there are more collision
- D. Due poor rearrangement of reacting particle

86. Why does reaction rate increases as the temperature increases?

- A. Particles begins to collide at higher temperature
- B. At higher temperature particles move faster and collide more often
- C. There is more particles at higher temperature, so the particles collide more
- D. Having smaller surface area at higher temperature.

87. When the system  $\text{A} + \text{B} \rightleftharpoons \text{C} + \text{D}$  is at equilibrium

- A. The sum of the concentration of A & B must be equal the sum of the concentration of C&D
- B. The forward reaction is stopped
- C. Both the forward and reverse reaction has stopped
- D. Neither r the forward nor the reverse reaction has stopped
- E. The reverse reaction has stopped

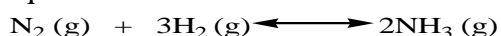
88. Which of the following is the proper term to describe equilibrium between different phases of matter?

- A. Heterogeneous equilibrium
- B. An endothermic equilibrium
- C. An exothermic equilibrium
- D. A homogeneous equilibrium

89. For  $2\text{SO}_3 \text{ (g)} \rightleftharpoons 2\text{SO}_2 \text{ (g)} + \text{O}_2 \text{ (g)}$  The conventional equilibrium constant for expression (KC) for the system as described by the above equation is:

- A.  $[\text{SO}_3]^2 / [\text{SO}_2]^2 [\text{O}_2]$
- B.  $[\text{SO}_3]^2 / [\text{SO}_2]^2 [\text{O}_2]$
- C.  $[\text{SO}_2]^2 [\text{O}_2] / [\text{SO}_3]^2$
- D.  $[\text{SO}_2]^2 [\text{O}_2]$

90. Consider the following reversible reaction. In a 3.00 liter container, the following amounts are found in equilibrium at 400 °c: 0.0420 mole of N<sub>2</sub>, 0.516 mole of H<sub>2</sub> and 0.0357mole of NH<sub>3</sub> .evaluate KC.



- A. 0.202
- B. 1.99
- C. 16.0
- D. 4.94
- E. 0.503

91. If equilibrium constant for the reaction  $\text{A} + 2\text{B} \rightleftharpoons \text{C} + 5/2 \text{D}$  has a value of 4.0, what is the value equilibrium constant for the reaction  $2\text{C} + 5\text{D} \rightleftharpoons 2\text{A} + 4\text{B}$  at the same temperature?

- A. 0.25
- B. 0.063
- C. 2.0
- D. 8.0
- E. 16.0

92. Which of the following is **not** a necessary condition to begin /start a chemical reaction?
- Proper orientation
  - Activation energy
  - Concentration of reactant
  - Collision between reacting particles
93. In which of the following statements can be made about KC, chemical reaction at equilibrium does not affected by the change of pressure?
- $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
  - $2\text{SO}_3(\text{g}) \rightleftharpoons 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$
  - $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$
  - $2\text{C}_2\text{H}_6(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$
94. At  $445^\circ\text{C}$ , KC for the reaction is 0.020
- $$2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$$
- A mixture of  $\text{H}_2$ ,  $\text{I}_2$  &  $\text{HI}$  in a vessel at  $445^\circ\text{C}$  has the following concentrations:  $[\text{HI}] = 2.00\text{M}$ ,  $[\text{H}_2] = 0.05\text{M}$  &  $[\text{I}_2] = 0.10\text{M}$ . Which one of the following statements concerning the reaction quotient, QC is true for the above system?
- QC=KC the system is at equilibrium
  - QC is less than KC, more  $\text{H}_2$  &  $\text{I}_2$  will be produced
  - QC is less than KC, more HI will be produced
  - QC is greater than KC, more  $\text{H}_2$  &  $\text{I}_2$  will be produced
  - QC is greater than KC, more HI will be produced
95. A quantity of HI was sealed in a tube, heated at  $425^\circ\text{C}$  & held at this temperature until equilibrium was reached the concentration of HI in the test tube at equilibrium was found to be  $0.0706\text{ mol/L}$ . Calculate the equilibrium concentration of  $\text{H}_2$  &  $\text{I}_2$  for the gas phase reaction.
- $$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g}), \text{KC} = 54.6 \text{ at } 425^\circ\text{C}$$
- $9.55 \times 10^{-3}\text{M}$
  - $4.78 \times 10^{-3}\text{M}$
  - $1.17 \times 10^{-3}\text{M}$
  - $1.85 \times 10^{-4}\text{M}$
  - $0.52\text{M}$
96. If a chemical reaction is at equilibrium, what can be said of the relative rates of the forward and reverse reaction?
- There is no net change in concentration reactant and product.
  - The forward reaction rate is greater than the reverse.
  - The reverse reaction rate is greater than the forward reaction.
  - More reactants are converted to product
97. Which of the following is **not** true about catalyst? Catalyst is:
- Substances that speed up chemical reaction by lowering its activation energy.
  - Substances that consumed during chemical reaction.
  - A bridge that allows things to happen.
  - It can be reused over a reaction.
98. Which of the following is **not** true about dynamic equilibrium?
- There is no net change in concentration of reactant and product.
  - Rate of forward reaction is equal rate of reverse reaction.
  - Reaction does not stop & both forward & reverse reaction continues at equal rate.
  - Rate of forward reaction is greater than rate of reverse reaction
99. What happens to the colour of permanganate ion solution in acidic medium?
- Colour less
  - Purple
  - Orange
  - Green

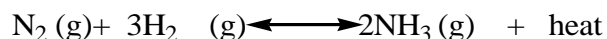
100. The role of oxidizing agent in reduction-oxidation reaction is:

- A. It self reduced by losing electrons
- B. Its number of electron decreases while its oxidation number decreases.
- C. Act as electron supplier for the red-ox reaction
- D. Act as electron acceptor in the red-ox reaction

101. Which of the following factors has **no** effect on the rate of chemical reaction?

- A. Change in surface area
- B. Change in concentration
- C. Change in temperature
- D. Colour change

102. Which of the following is **not** true about the reaction given below exist at equilibrium condition?



- A. Increasing pressure of the reaction shifts equilibrium toward product side.
- B. Increasing temperature of the reaction shifts equilibrium toward product side.
- C. Decreasing volume of the reaction shifts equilibrium toward product side.
- D. Decreasing temperature of the reaction shifts equilibrium toward product side.

103. Which of the following factors does **not** affect reactions exist at equilibrium condition?

- A. Addition of concentration of reacting particles.
- B. Increasing or decreasing pressure of reacting particles.
- C. Increasing or decreasing temperature of reacting particles.
- D. Addition of catalyst to the system.

104. Given the system at equilibrium:  $\text{N}_2\text{O}_4(\text{g}) + 58.1\text{KJ} \rightleftharpoons 2\text{NO}_2(\text{g})$

What will be the effect of decreasing in temperature of the system at constant pressure?

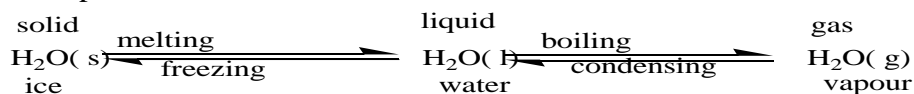
- A. The equilibrium will shift to the right, and concentration of  $\text{NO}_2(\text{g})$  will increase.
- B. The equilibrium will shift to the right, and concentration of  $\text{NO}_2(\text{g})$  will decrease.
- C. The equilibrium will shift to the left, and concentration of  $\text{NO}_2(\text{g})$  will increase.
- D. The equilibrium will shift to the left, and concentration of  $\text{NO}_2(\text{g})$  will decrease.

## 5. PHYSICAL STATE OF MATTER

**Matter:** is anything that can occupy space and has mass.

It exists in different form.

Example: water exist as



### The kinetic theory of matter

- ❖ It gives explanation based on nature of motion and heat energy of particles.
- ❖ According its theory every substance compose of large number very small size particles called ions, atoms and molecules.
- ❖ These particles are in state of continuous and rapid motion with all possible velocity.

### Comparison between these particles

particles	motion of molecules	distance b/n molecules	attractive force b/n molecules
1. Gas	high	very far apart	very low
2. Liquid	medium	close to each other	medium
3. Solid	low	very close to each other	high

105. A substance has freezing point of  $-10^{\circ}\text{C}$  and a boiling point of  $325^{\circ}\text{C}$ . At what temperature would this substance be in its liquid state?  
 A.  $-100^{\circ}\text{C}$       B.  $375^{\circ}\text{C}$       C.  $75^{\circ}\text{C}$       D.  $-25^{\circ}\text{C}$
106. Which of the following correctly compares the relative distances between the particles of most substances in their solid (S), liquid (L) and gas (G) states respectively from weaker to stronger?  
 A.  $S < L < G$       B.  $S < G < L$       C.  $L < S < G$       D.  $G < L < S$
107. Which statement best describes the particles of an ideal gas according to the kinetic molecular theory?  
 A. The gas particles are arranged in a regular geometric pattern  
 B. The gas particles are separated by very small distances, relative to their sizes.  
 C. The gas particles are in random and continuous motion  
 D. The gas particles are strongly attracted to each other.

## properties of matter based on assumption of kinetic theory

the assumption generally based on

I. all matter composed of particles which are in a constant motion.

II. The particles possess kinetic energy and potential energy.

III. The difference b/n three states of matter is due to their energy content & the motion of particles.

Gas	Liquid	Solid
1. have no definite shape and volume	-have definite volume but no definite shape	-have definite shape and volume
2. easily compressed compared liquid and solid	-compressed compared to solid but less than gas	-difficult to compress
3. have low density b/c its particles are far apart and number of molecules per unit volume is very small.	-have higher densities than gas	-have higher density than gas & liquid.
4. exerts pressure in all directions to the walls of container in w/c it is confined.	--	--
5. highly flow and diffuse through one another (are fluids)	-Fluids-easily flow naturally down hill b/c of gravity.	-Are not fluids
6. molecules move freely (its particles translate of course gas molecules rotate & vibrate)	-its molecules vibrate but it rotates due to freedom of it to assume shape of container it is poured in.	-its particles only vibrate at a fixed point with respect to neighbouring particles.

**Freezing point:** is a temperature at which liquid substances/liquid phase changed to liquid state.

Example freezing point of water is equal to  $0^{\circ}\text{C}$ .

**Melting point:** is a point at which solid phase changed to liquid phase.

Example melting point of water is equal to  $0^{\circ}\text{C}$ .

**Boiling point:** is a point at which liquid phase changed to gas phase.

Example boiling point of water is equal to  $100^{\circ}\text{C}$ .

**Sublimation:** is a process by which solid substances directly converted to gas phase without forming liquid state.

Evaporation- is process by which liquid molecules break freely from the surface & enter to vapour phase (gaseous state).

✓ Explained in terms of energy processed by molecules on the surface of liquid.



✓ Its rate of evaporation increased as temperature increased.

Rate of evaporation based on three factors

- Intermolecular forces of attraction.
- Temperature (as altitude increase atmospheric pressure decrease).
- Surface area.

## Liquid

### Volatile liquid

Evaporate readily at room temperature  
Have weak intermolecular forces among its molecules/particles.  
Have high vapour pressure  
Relatively non-polar with weak dispersion forces  
Ex. benzene, diethyl ether etc

### Non-volatile liquid

-Low tendency to evaporate at room temp.  
-Relatively strong.  
-Relatively have low vapour pressure.  
-More of polar & molten form of ionic compd.  
Ex.  $H_2O$ ,  $H_2SO_4$ , liquid form of mercury etc

108. The average kinetic energy of colliding particles can be increased by

- |                            |                                       |
|----------------------------|---------------------------------------|
| A. Adding a catalyst.      | C. increasing pressure.               |
| B. Increasing temperature. | D. increasing reactant concentration. |

109. What will be the new volume of gas that occupies 10ml, in which its pressure be doubled at constant temperature?      A. 25 ml      B. 20 ml      C. 5 ml      D. 15 ml

**Boyle's law:** states that volume of a fixed mass of gas is inversely proportional to pressure at constant temperature.

$$V = k \frac{1}{p}, \text{ Where } k \text{ is proportionality constant.}$$

110. A gas in a balloon occupies 20.0L at a pressure of 25 atm. If the temperature of a balloon kept constant, at what pressure the volume of gas is doubled?

- |           |          |             |            |
|-----------|----------|-------------|------------|
| A. 50 atm | B. 5 atm | C. 12.50atm | D. 250 atm |
|-----------|----------|-------------|------------|

111. If 11.2m<sup>3</sup> of hydrogen combined with 33.6 L of chlorine at STP, then the volume of product formed from the reaction of hydrogen & chlorine?

- |                            |                           |
|----------------------------|---------------------------|
| A. 67.2 L of HCl is formed | C. 44.8L of HCl is formed |
| B. 22.4L of HCl is formed  | D. 5.6 L of HCl is formed |

112. Which one of the following is true about the rate of diffusion of given pair of gases?

- |   |   |
|---|---|
| A. $N_2$ diffuses faster than $CH_4$ .    | C. $O_2$ diffuses faster than $N_2$ .     |
| B. $NO_2$ diffuses faster than $N_2O_4$ . | D. $C_2H_4$ diffuses faster than $C_2H_2$ |

**NB Graham's law of diffusion:** states that at constant temperature and pressure the rate of diffusion of gas, r, is inversely proportional to the square root of its density / molar mass.

- ✓ Rate of diffusion is different for different gases.
- ✓ Is dependent of its density/molar mass.
- ✓ The higher its density or its molar mass the slower is its rate of diffusion.
- ✓ Rate of diffusion is depending on attractive force between gas particles (the weaker the attractive force of attraction is the faster its rate of diffusion).
- ✓ It depend on the diameter of the gas (the smaller its diameter of the gas the faster its rate of diffusion).

- ✓ Depend on the speed of gas particles (the higher the speed of Gas particle the faster is the rate of its diffusion.

Mathematically it can be expressed as:

$$r \propto \sqrt{\frac{1}{d}} \quad \text{or} \quad r \propto \sqrt{\frac{1}{M}} ;$$

Where r is the rate of diffusion, d is the density and M is the molecular mass of the gas. For two gases (Gas 1 and Gas 2), their rates of diffusion can be given as:

$$\begin{aligned} r_1 &\propto \sqrt{\frac{1}{d_1}} & \text{or} & & r_1 &\propto \sqrt{\frac{1}{M_1}} \\ r_2 &\propto \sqrt{\frac{1}{d_2}} & \text{or} & & r_2 &\propto \sqrt{\frac{1}{M_2}} \end{aligned}$$

and

$$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} \quad \text{or} \quad \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} ;$$

Rearranging these relationships gives the following expression

$$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} \quad \text{or} \quad \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}} ;$$

Where  $r_1$ ,  $d_1$  and  $M_1$  represent the rate of diffusion, density and molecular mass of gas 1.  $r_2$ ,  $d_2$  and  $M_2$  represent the rate of diffusion, density and molecular mass of gas 2.

113. Which one of the following is true about Boyle's studies on pressure and volume?
- The volume of gases increases as the pressure of gas increases.
  - The volume of gases doubles as the pressure of gas increases.
  - The volume of gases decreases as the pressure of gas increases.
  - The volume of gases remains the same as the pressure of gas changed.
114. Which one of the following is true about Grham's law of diffusion of particles?
- Particles with heavier mass diffuse faster as compared to particles with smaller mass.
  - Rate of diffusion is directly proportional to mass of the particles.
  - Rate of diffusion particles is directly proportional to the square root of mass.
  - Rate of diffusion particles is inversely proportional to the square root of mass.
115. The rate of diffusion of  $\text{SO}_2$  as compared to diffusion of gas  $\text{CH}_4$  is:
- $\text{SO}_2$  twice as fast as gas  $\text{CH}_4$
  - $\text{SO}_2$  one half as fast as gas  $\text{CH}_4$
  - $\text{SO}_2$  four as fast as gas  $\text{CH}_4$
  - $\text{SO}_2$  one fourth as fast as gas  $\text{CH}_4$
116. What must be the molecular mass of a gas that diffuses one fourth times as rapidly as methane ( $\text{CH}_4$ )? (At. Mass: C=12, H=1)
- 4
  - 16
  - 64
  - 256
117. What is the average velocity of hydrogen molecule at  $0^\circ\text{C}$ ; if the average velocity of oxygen molecule at this temperature is 300 m/s?
- 9600m/s
  - 4800 m/s
  - 3200 m/s
  - 1200m/s
118. Each of the following jars contains the same number of molecules, at the same temperature. In which of this jar the pressure exerted is high?
- 1 liter jar
  - 5 liter jar
  - 10 liter jar
  - 25 liter jar
119. At constant pressure the volume of a fixed mass of any gas is directly proportional to the absolute temperature, which of the following expression does **not** represent the above statement?
- $V \propto T$
  - $V_1 T_1 = V_2 T_2$
  - $V_1 T_2 = V_2 T_1$
  - $V/T = K$  (at constant pressure).

120. The volume of a gas filled in a balloon is 50.0L at 20.0°C and 742 torr. What volume it occupy at standard temperature and volume (STP)?  
 A. 45.5L      B. 909.6L      C. 2717L      D. 90.1L
121. What is the molar mass of a 0.286g sample of a certain gas occupies 50.0mL at standard temperature and 76.0 cm Hg?  
 A. 32g/mol      B. 64 g/mol      C. 128 g/mol      D. 1.68 g/mol
122. Which order of the following is true about gases when they are arranged according to their increasing order of their densities at STP?  
 (Given: H<sub>2</sub>, CO, SO<sub>3</sub>, NO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>O, POF<sub>3</sub>, SO<sub>2</sub>)  
 A. H<sub>2</sub>, CO, SO<sub>3</sub>, NO<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>O, POF<sub>3</sub>, SO<sub>2</sub>      C. SO<sub>3</sub>, POF<sub>3</sub>, SO<sub>2</sub>, NO<sub>2</sub>, N<sub>2</sub>O, O<sub>2</sub>, CO, H<sub>2</sub>  
 B. O<sub>2</sub>, N<sub>2</sub>O, POF<sub>3</sub>, SO<sub>2</sub>, H<sub>2</sub>, CO, SO<sub>3</sub>, NO<sub>2</sub>      D. H<sub>2</sub>, CO, O<sub>2</sub>, N<sub>2</sub>O, NO<sub>2</sub>, SO<sub>2</sub>, SO<sub>3</sub>, POF<sub>3</sub>

NB: **Avogadro's law** this law states that equal volume of different gases contain the same number of molecules.

Or 1 mole of any gas occupies 22.4 liter at STP.

STP means measured at standard temperature & pressure.

123. Which of the following is **not** true about water molecules?  
 A. Boiling point and condensation co-exist at the same temperature  
 B. Water in the form of liquid floats over water exists in the form of solid.  
 C. Water in the form of solid floats over water exists in the form of liquid.  
 D. Inter molecular attraction between liquid water is greater than that of ice. This due to hydrogen bonding experienced in water.
124. Which one of the following is true about the properties of solid?  
 A. Molecules only vibrate but they rotate well, giving freedom to assume shape of container  
 B. Exist as a gaseous mixtures of positive ions and electrons  
 C. Having definite shape but not have definite volume.  
 D. Completely incompressible and having very high average density.

Ideal gas law: is an hypothetical gas that obeys the gas law.

it is a combination of the three gas laws

1. Boyle's law    2. Charles's law    3. Avogadro's law

$PV=nRT$ ,    R-proportionality constant (gas constant)

$R=0.082 \text{ L.atm./K.mol}$

But  $n = \frac{m}{M}$ , m=actual/given mass in gram(g)  
 M=molar mass in gram per mole(g/mol)

$$PV = \frac{m}{M} RT \Rightarrow PVM = mRT \text{ divide both side by } V.$$

$$PM = \frac{mRT}{V} \text{ but } m/v=d, d=\text{density}$$

$$PM = dRT$$

$$R = \frac{PV}{nT} = \frac{(1 \text{ atm})(22.414 \text{ L})}{(1 \text{ mol})(273.15 \text{ K})}$$

$$= 0.082057 \frac{\text{L.atm}}{\text{K.mol}} = 8.314 \text{ L.kPa/K.mol} = 8.314 \text{ J/mol.K}$$

For calculations, we round off the value of R to three significant figures (0.0821 L.atm/K.mol) and use 22.4 L for the molar volume of a gas at STP.

125. What is the volume of 2.8 g of nitrogen gas at 27 °C and 2 atmospheres?

(Given:  $R=0.082 \text{ L} \cdot \text{atm} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ , molar mass:  $\text{N}_2=28 \text{ g/mol}$ ).

- A. 2.463 L    B. 12.315 L    C. 1.2315 L    D. 24.63 L

Real Gas- is a gas that does not behave as an ideal gas due to interaction between gas molecules.

- it is also known as non-ideal gas.

- it behaves as an ideal gas at low pressure and high temperature.

- it does not have a finite volume & exerts no attractive force to each other.

126. Which one of the following is not true about real gas?

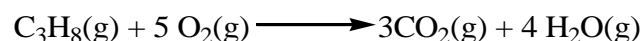
A. Real gas behaves ideally at low pressure and high temperature.

B. The molecules in ideal gas do not have a finite volume and exert no attractive force.

C. Molecules in real gas are far apart and exert little or no attractive force among them.

D. Molecules in real gas are closer to one another and exert little or no attractive force among them.

127. What volume of oxygen will react with 15.0 L of propane ( $\text{C}_3\text{H}_8$ ) to form carbon dioxide and water? What volume of carbon dioxide will be formed? What volume of water vapor will be formed respectively at STP?



- A. 45 L, 60 L & 75 L    B. 75 L, 45 L & 60 L    C. 60 L, 45 L & 70 L    D. 60 L, 45 L & 70 L

128. If the molar mass of a given gas is 20 g/mol at STP, what is the density of this gas?

- A. 678.17 g/L    B. 6.696 g/L    C. 89.1 g/L    D. 0.89 g/L

129. The amount of heat energy absorbed by the solid substances to be converted to liquid state is:

A. Molar heat of crystallization

C. Molar heat of solidification

B. Molar heat of fusion

D. Molar heat of Vaporization

130. How do the particles of a gas move?

A. Particles in a gas vibrate in place

C. Particles in a gas slide past each other

B. Particles in a gas are close together

D. Particles in a gas move rapidly

131. Which of the following correctly pairs a phase of matter with its description?

A. Liquid: particles are more strongly attached to one another than in solid phase.

B. Gas: particles have higher force of attraction than liquids

C. Solid: particles in the solid phase have higher kinetic energy than the others

D. Solid: particles are more strongly attached to one another than others.

132. Which of the following is **NOT** correctly stated according to the kinetic theory of gases?

A. There are forces of attraction or repulsion between gas particles.

B. Gas particles are far apart.

C. Gas particles are in rapid, random and continuous motion.

D. Gas particles are easily compressed.

133. At what temperature will a gas occupy 200 cm<sup>3</sup> at 112 kPa if it occupies 400 cm<sup>3</sup> at 32 °C and 112 kPa?

- A. 252.5 K    B. 105.5 K    C. 165.5 K    D. 152.5 K

134. A solid is a state of matter that has a;

A. Definite volume and a definite shape

C. Indefinite volume and indefinite shape

B. Indefinite volume and a definite shape

D. Indefinite shape and definite volume

135. Which of the following definitions is wrong?

A. The amount of heat required to transform a liquid into a gas is called molar heat of vaporization

B. The amount of heat required to melt a solid state is called molar heat of fusion

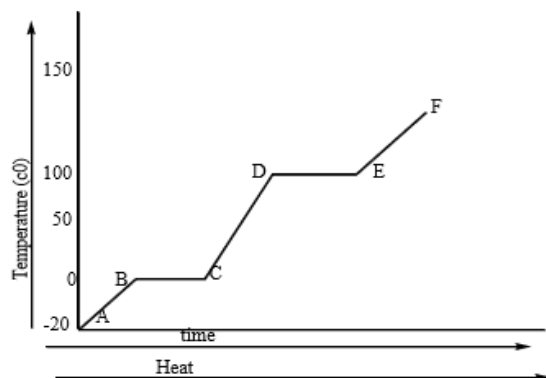
C. The temperature at which a solid melts is called melting point

D. The molar heat of vaporization is the same as molar heat of fusion.

136. Which assumption of kinetic molecular theory of gases is not true?

- A. Gases expanded more freely as compared to liquid and solids.
- B. Gases are spontaneously intermixing with one other.
- C. Gases are incompressible as compared to liquids and solids.
- D. Gases have high kinetic energy as compared to liquids and solids.
- E. All assumptions are true about kinetic molecular theory of gases.

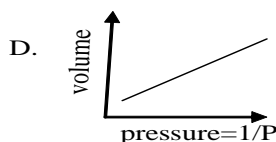
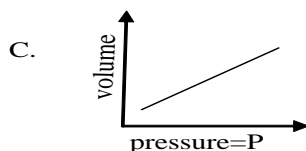
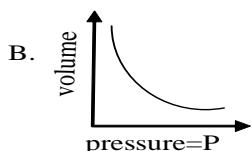
137. The following figure shows the change in temperature as a solid substance is heated.



Which letter in the path represents the co-existence of solid with liquid and liquid with gas phase respectively?

- A. Path A to D and B to C
  - B. Path B to C and C to D
  - C. Path B to C and D to E
  - D. Path A to C and C to E
138. Which of the following is not true about Boyle's law?

A. Pressure and volume are inversely related one another at constant temperature.



139. Which of the following statement is correct regarding the Collision theory?

- I. The particles of reacting species must collide.
  - II. The particles of reacting species should randomly orient.
  - III. The particles of reacting species should be properly oriented.
  - IV. When reacting species collide, they should have insufficient energy needed to break the existing bond to form a new bond.
  - V. When reacting species collide, they should have sufficient energy which is either equal to or greater than activation energy ( $E_a$ ) to break the old bond and form the new bond.
- A. II, III, & V    B. I, III & V    C. II & IV only    D. II & V only

## Chemical Bonding and Intermolecular Forces

140. The concepts of "like dissolve like" is illustrated by which one of the following?

- A. NaCl is more soluble in  $\text{CCl}_4$  than in water.
- B.  $\text{I}_2$  is more soluble in  $\text{CCl}_4$  than water.
- C. NaCl is more soluble in both  $\text{CCl}_4$  and water.
- D.  $\text{I}_2$  is more soluble in water than in  $\text{CCl}_4$ .

141. Which of the following intermolecular force account for the fact those noble gases can liquefy?
- A. London dispersion force.                      C. Dipole –dipole force  
B. Hydrogen bonding.                              D. coordinate/dative bond
142. The boiling point of  $\text{CH}_4$  is much lower than that of  $\text{HF}$ . This is because of ;
- A. dipole –dipole interaction in  $\text{CH}_4$   
B.  $\text{HF}$  is non-polar covalent molecule.  
C.  $\text{CH}_4$  is polar covalent molecule.  
D. Hydrogen bonding in  $\text{HF}$ .
143. Which of the following is **NOT** true regarding to metallic bonding?
- A. Metals are a matrix of positively charged ion and delocalized electrons.  
B. Compared to other types of bonding metallic bonding is quite different.  
C. The valence electrons of metal atoms are localized.  
D. Metallic bonding forms crystals of the metal rather than compound.
144. Which one of the following molecules has the strongest intermolecular force of attraction?
- A.  $\text{NH}_3$                       B.  $\text{O}_2$                       C.  $\text{CH}_4$                       D.  $\text{CO}_2$
145. Which of the following lists correctly shows the strength of the intermolecular attractive force in **decreasing** order?
- A. London force, dipole-dipole interaction and hydrogen bonding.  
B. Hydrogen bond, dipole-dipole interaction and London force.  
C. Dipole-dipole interaction, hydrogen bonding and London force.  
D. Hydrogen bond, London force and dipole-dipole interaction
146. One of the following substances contains hydrogen bonding?
- A. Methane                      B. Hydrogen chloride                      C. Sulphur dioxide                      D. Ammonia.
147. Which one of the following properties is characteristic to covalent compounds?
- A. They can exist in three physical state of matter.  
B. They have relatively high melting and boiling points.  
C. All covalent molecules can conduct electricity in aqueous solution.  
D. All covalent molecules are soluble in polar solvents.
148. The number of lone pair and bonding pair electron existing in carbon disulfide ( $\text{CS}_2$ ) molecule?
- A. 3 bonding pairs and 2 lone pairs                      C. 4 bonding pairs and 8 lone pairs  
B. 4 bonding pairs and 4 lone pairs                      D. 2 lone pairs and 2 bonding pairs.

**THE END!!!**

**PRACTICE MAKE YOU PERFECT!!!!!!!**

## Answer Key

1.C	36.A	77.C	111.A
2.B	37.C	78.B	112.B
3.C	38.C	79.B	113.C
4.D	39.B	80.D	114.D
5.A	40.A	81.B	115.B
6.B	41.A	82.B	116.D
7.B	42.C	83.B	117.D
8.D	43.B	84.A	118.A
9.E	44.D	85.A	119.B
10.B	45.A	86.B	120.A
11.B	46.A	87.D	121.C
12.D	47.C	88.A	122.D
13.D	48.D	89.C	123.B
14.D	49.B	90.A	124.D
15.x=867.67 g of CaCl <sub>2</sub> is formed.	50.C	91.A	125.C
16.B	51.C	92.C	126.D
17.2.25 mol of H <sub>2</sub> O was needed.	52.B	93.C	127.B
18. C	53.B	94.C	128.D
19.B	54.A	95.A	129.B
20.D	55.B	96.A	130.D
21.C	56.B	97.B	131.D
22.A	57.B	98.D	132.A
23.C	58.D	99.A	133.D
24 .83%	59.B	100.A	134.A
25. 81.9%	60.C	101.D	135.D
26.A=79.33%,B=76%	61.B	102.B	136.C
27.B	62.B	103.D	137.C
28.----	63.B	104.D	138.C
29.B	64.B	105.C	139.B
30.C	65.A	106.D	140.B
31.B	66.A	107.C	141.A
32.A	67.C	108.B	142.D
33.A	68D	109.C	143.C
34.C	69.B	110.C	144.A
35.D	70.D		145.B
	71.D		146.D
	72.A		147.A
	73.C		148.B
	74.B		
	75.C		
	76.D		