

**MINISTRY OF SCIENCE AND TECHNOLOGY**

**DEPARTMENT OF TECHNICAL AND VOCATIONAL  
EDUCATION**

**Sample Questions & Worked Out  
Examples  
For  
E.Sc 01011  
ENGINEERING SCIENCE**

**A.G.T.I.(First Year)**

**Engineering Students**

## **Part One**

## Chapter ( 1 )

### 1. Define the terms:

**Radioactivity** : Radioactivity is a natural phenomenon that is spontaneous emission of radiation by mineral sources.

**Isotopes** : Two or more atoms having the same atomic number but different mass numbers are called isotopes.

**Atomic mass** :

$$\text{Atomic mass of an element} = \left[ \begin{array}{cc} \text{mass of} & \text{fractional} \\ \text{isotope(1)} & \times \text{abundance of} \end{array} \right] \text{isotope(1)} + \left[ \begin{array}{cc} \text{mass of} & \text{fractional} \\ \text{isotope (2)} & \times \text{abundance of} \end{array} \right] \text{isotope(2)}$$

**A mole** : A mole is the amount of substance that contains of a number of chemical units equal to the number of atoms in exactly 12 g of pure carbon-12.

### 2. Describe the characteristics of alpha, beta, gamma rays.

**Alpha rays** : Alpha rays are particles carrying two fundamental units of positive charge and having the same mass as helium atom.

**Beta rays** : Beta rays are negatively charged particles produced by changes occurring within the nuclei of radioactive atoms and have the same properties as electrons.

**Gamma rays** : Gamma rays are electromagnetic radiation of extremely high penetrating power.

### 3. Write an account for cathode rays.

In passing electricity through evacuated glass tubes, a type of radiation emitted by the negative terminal (cathode) that crossed the evacuated tube to the positive terminal (anode).

Cathode rays travel in straight line and have properties that are independent of the cathode material

Cathode rays are deflected by electric and magnetic fields.

Cathode rays are negatively charged fundamental particles of matter found in all atoms and becomes known as electrons.

### 4. What is the significant features of nuclear atom

- Most of the mass and all of the positive charge of an atom are centered in a very small region called the nucleus. The atom is mostly empty space.
- The magnitude of the positive charge is different for different atoms and is approximately one half the atomic weight of the element.
- There exist as many electrons outside the nucleus as there are units of positive charge on the nucleus. The atom as a whole is electrically neutral.

5. The two isotopes of  ${}^6\text{Li}$  and  ${}^7\text{Li}$  have masses of 6.01513 and 7.01601 u. The average atomic mass of lithium is 6.941 u.

(a) Which of these two isotopes is more abundant?

(b) Calculate the percent natural abundance of the two.

(a) Lithium (7) is more abundant because the weighted average atomic mass (6.941 u) is much closer to (7) than to (6).

(b) The fractional abundance of  ${}^6\text{Li}$  isotope = (x)  
 -----  
 ${}^7\text{Li}$  isotope = (1 - x)

$$\begin{aligned} \text{Atomic mass of an element} &= \left[ \begin{array}{cc} \text{mass of} & \text{fractional} \\ \text{isotope (1)} & \text{abundance of} \end{array} \right] + \left[ \begin{array}{cc} \text{mass of} & \text{fractional} \\ \text{isotope (2)} & \text{abundance of} \end{array} \right] \\ & \qquad \qquad \qquad \text{isotope (1)} \qquad \qquad \qquad \text{isotope (2)} \\ \text{Atomic mass of Li} &= [(x) \times 6.01513 \text{ u}] + [(1-x) \times 7.01601 \text{ u}] \\ 6.941 \text{ u} &= 6.01513x + 7.01601 - 7.01601x \\ x &= 0.074944 \end{aligned}$$

$$\begin{aligned} \text{The \% abundance. of } {}^6\text{Li isotope} &= 0.074944 \times 100\% \\ &= 7.4944\% \end{aligned}$$

$$\text{The \% abundance. of } {}^7\text{Li isotope} = (100 - 0.074944) \times 100\% = 92.5056 \%$$

6. The percent abundance of  ${}^{40}\text{K}$  atom is 0.012%. How many  ${}^{40}\text{K}$  atom do you ingest by drinking one cup of milk containing 371 mg of K? (K = 39.098)

$$\begin{aligned} (?) \text{ } {}^{40}\text{K atoms} &= 371 \times 10^{-3} \text{ g K} \times \frac{1 \text{ mol K}}{39.0983 \text{ g K}} \\ &\quad \times \frac{6.022 \times 10^{23} \text{ atom K}}{1 \text{ mol K}} \times \frac{0.012 \text{ atom } {}^{40}\text{K}}{100 \text{ atom K}} \\ &= 6.8570 \times 10^{17} \text{ atom } {}^{40}\text{K} \end{aligned}$$

7. What is the mass, in gram, corresponding to 1.000 u.?

$$\begin{aligned} (?) \text{ g} &= 1 \text{ u} \times \frac{1 \text{ atom } {}^{12}\text{C}}{12 \text{ u}} \times \frac{1 \text{ mol } {}^{12}\text{C}}{6.02 \times 10^{23} \text{ } {}^{12}\text{C atoms}} \times \frac{12 \text{ g } {}^{12}\text{C}}{1 \text{ mol } {}^{12}\text{C}} \\ &= 1.6605 \times 10^{-24} \text{ g} \end{aligned}$$

8. For the nuclide  $^{133}_{55}\text{Cs}$ , express the percentage, by number of the fundamental particles in the nucleus that are neutrons.

Total particles in the nucleus = 133

No: of neutron in the nucleus =  $133 - 55 = 78$

(%) neutrons in the nucleus =  $\frac{78}{133} \times 100\% = 67\%$

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## Chapter ( 2 )

1. What is meant by the following terms:

**Electromagnetic radiation:** Electromagnetic radiation is a form of energy transmission through a vacuum or medium in which electric and magnetic fields are propagated as wave.

**Atomic Spectra** : The spectra produced by certain gaseous substances consist of only a limited number of colored lines with dark spaces between them. These discontinuous spectra are called atomic spectra

**Stationary States** : The electron has only a fixed set of allowed orbits, called stationary states.

**Pauli Exclusion Principle** : No two electrons in an atom may have all four quantum numbers alike.

**Hund's rule** : When orbitals of identical energy are available, electrons initially occupy these orbitals singly.

2. How many quantum numbers are required to specify an electron in a single orbital and what are the values?

The four sets of quantum numbers.

(i) Principle Q.no. (n)	$n = 1, 2, 3, \dots, n$
(ii) Orbital Q.no. (l)	$l = 0, 1, 2, \dots, (n-1)$
(iii) Magnetic Q.no. ( $m_l$ )	$(m_l) = +l \dots 0 \dots -l$
(iv) Spin Q.no. (n)	$m_s = +\frac{1}{2}, -\frac{1}{2}$

3. What type of orbital is designated (a)  $n = 2, l = 1$ , (b)  $n = 4, l = 2$ .  
(c)  $n = 5, l = 0$  ?

$$n = 2, l = 1 \rightarrow 2p$$

$$n = 4, l = 2 \rightarrow 4d$$

$$n = 5, l = 0 \rightarrow 5s$$

4. Calculate the energy emitted by the light of a sodium vapor lamp which has wavelength of 589 nm. ( $h = \text{plank's constant} = 6.626 \times 10^{-34} \text{ J s}$ ,  $c = 2.998 \times 10^8 \text{ ms}^{-1}$ )

$$\begin{aligned} \lambda &= 589 \text{ nm} = 589 \times 10^{-9} \text{ m} \\ E &= \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \text{ Js photon}^{-1} \times 2.998 \times 10^8 \text{ ms}^{-1}}{589 \times 10^{-9} \text{ m}} \\ &= 3.3748 \times 10^{-19} \text{ J/photon} \end{aligned}$$

5. How long does it take light from the sun 93 million miles away to the earth?  
 $c = 2.998 \times 10^8 \text{ ms}^{-1}$ , (1 mile = 1.60931 km)

$$\begin{aligned} 93 \text{ million miles} &= 93 \times 10^6 \text{ miles.} \\ (?) \text{ second} &= 93 \times 10^6 \text{ miles} \times \frac{1.60931 \text{ km}}{1 \text{ mile}} \times \frac{10^3 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ s}}{2.988 \times 10^8 \text{ m}} \\ &= 499.2189 \text{ s} \end{aligned}$$

6. Calculate the velocity of a beam of photon moving with a wavelength of 10pm.  
mass of proton =  $1.67 \times 10^{-24} \text{ g}$ ,  $h = \text{plank's constant} = 6.626 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}$ )

$$\begin{aligned} \lambda &= 10 \text{ pm} = 10 \times 10^{-12} \text{ m} \\ m &= 1.67 \times 10^{-24} \text{ g} = 1.67 \times 10^{-27} \text{ kg} \end{aligned}$$

$$\lambda = \frac{h}{mv}$$

$$\begin{aligned} v &= \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}}{1.67 \times 10^{-27} \text{ kg} \times 10 \times 10^{-12} \text{ m}} \\ v &= 3.9676 \times 10^4 \text{ m s}^{-1} \end{aligned}$$

7. Calculate the wavelength of an alpha particles if its velocity is  $1.5 \times 10^7 \text{ m s}^{-1}$ .  
Avogadro's no, =  $6.02 \times 10^{23}$ ,  $c = 2.998 \times 10^8 \text{ ms}^{-1}$ ,  $h = 6.626 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}$ ,  
( alpha particles =  ${}^4_2\text{He}^{2+}$ )

$$\alpha \text{ particle} = {}^4_2\text{He}^{2+}$$

$$\text{molar mass of He} = 4 \text{ g/mol}$$

$$\begin{aligned} (?) \text{ g of one } \alpha \text{ particle} &= \frac{4\text{g}}{1\text{ mol}} \times \frac{1\text{ mol}}{6.022 \times 10^{23} \text{ particles}} \\ &= 6.6423 \times 10^{-24} \text{ g / particles} \end{aligned}$$

$$m = 6.6423 \times 10^{-24} \text{ g} = 6.6423 \times 10^{-27} \text{ kg}$$

$$\begin{aligned} \lambda &= \frac{h}{mv} = \frac{6.626 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}}{6.6423 \times 10^{-27} \text{ kg} \times 1.5 \times 10^7 \text{ ms}^{-1}} = 6.65 \times 10^{-15} \text{ m} \\ &= 6.65 \times 10^{-6} \text{ nm} \end{aligned}$$

**8. The ionization energy of Na is 496 kJ mol<sup>-1</sup>. What is the wavelength of a photon that will cause this ionization?**

$$E = \frac{496 \times 10^3 \text{ J}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{6.023 \times 10^{23} \text{ photons}} = 82.3646 \times 10^{-20} \text{ J/photon}$$

$$E = h \frac{c}{\lambda}$$

$$\begin{aligned} \lambda &= \frac{hc}{E} = \frac{6.626 \times 10^{-34} \text{ Js} \times 2.998 \times 10^8 \text{ ms}^{-1}}{82.3646 \times 10^{-20} \text{ J}} \\ &= 2.4118 \times 10^{-7} \text{ m} \\ &= 241.18 \text{ nm} \end{aligned}$$

**9. Describe four sets of quantum numbers for a last added electron of the following elements. State whether they are paramagnetic or diamagnetic.**

	m	l	m <sub>l</sub>	m <sub>s</sub>
<sup>19</sup> K = [ Ar ] 4s <sup>1</sup>	4	0	0	$+\frac{1}{2}$
<sup>32</sup> Ge = [ Ar ] 4s <sup>2</sup> 3d <sup>10</sup> 4p <sup>2</sup>	4	1	0	$+\frac{1}{2}$
<sup>16</sup> S = [ Ne ] 3s <sup>2</sup> 3p <sup>4</sup>	3	1	-1	$-\frac{1}{2}$
<sup>12</sup> Mg = [ Ne ] 3s <sup>2</sup>	3	0	0	$-\frac{1}{2}$

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## Chapter ( 3 )

1. (a) Define the term ionization energy.

(b) Are there any atoms for which the second ionization energy is larger than the first? Explain.

- (a) The ionization energy is the quantity of energy a gaseous atom must absorb so that an electron is stripped from the neutral atom.  

$$\text{Na}_{(g)} \rightarrow \text{Na}^+_{(g)} + e^-$$
- (b) Second ionization energy is always greater than the first ionization energy, because the electron must be removed from a positively charged ion. The attraction between the positive ion and the electron is stronger than between the neutral atom and the electron.

2. Compare the elements K and Ca with respect to the following properties,

(a) Electron configuration

(b) Most common ionic charge

(c) First ionization energy

(d) Atomic radius.

	<b>K</b>	<b>Ca</b>
(a)	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$
(b)	+1	+2
(c)		K < Ca
(d)		K > Ca

3. Arrange the following elements in order of increasing their melting point

(a) Na, Si, Al and Mg. (b) CBr<sub>4</sub>, CCl<sub>4</sub>, CH<sub>4</sub>

(a) Na < Mg < Al < Si (b) CH<sub>4</sub> < CCl<sub>4</sub> < CBr<sub>4</sub>

The larger the molecular mass, the stronger intermolecular forces, the higher the melting point.

4. (a) Which one is better reducing agent, Mg or Al?

(a) Al has lower ionization energy than Mg and thus is more easily oxidized. Therefore Al is better reducing agent.

(b) Which one is better oxidizing agent, Cl or Br?

(c) Cl has higher electron affinity than Br and thus is more easily reduced. Therefore Cl is better oxidizing agent.

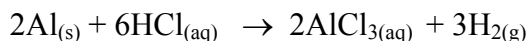
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## Chapter ( 4 )

### 1.Explain the terms:

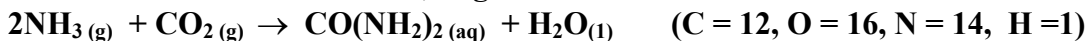
<b>Limiting reactant.</b>	The reactant that is completely consumed in a reaction is known as limiting reactant.
<b>Theoretical yield</b>	The calculated quantity of product in a chemical reaction is called theoretical yield of a reaction.
<b>Consecutive reaction</b>	Reactions that are carried out one after another in sequence to yield a final product are called consecutive reactions.
<b>Simultaneous reaction.</b>	In simultaneous reactions two or more substances react independently of each other in separate reactions occurring at the same time.
<b>Strong electrolyte</b>	Strong electrolyte is completely ionized in water solution, and the solution is a good electrical conductor.
<b>Weak acid</b>	Weak acid Acids that are incompletely (partially) ionized in aqueous solution are called weak acids.
<b>Oxidizing agents</b>	The substance that causes some other substance to be oxidized and itself reduced.

**2. An alloy used in fabricating aircraft structures consist of 93. 7% Al and 6.3% Cu by mass. The alloy has a densily of 2. 85 g cm<sup>-3</sup>. What volume of the Al-Cu alloy must be dissolved in an excess of HCl<sub>(aq)</sub> to produce 1 g H<sub>2</sub>? If one assumes that all the Al, but none of the Cu. reacts with HCl(oq)  
( H = 1, Al = 27 ).**



$$\begin{aligned} (?) \text{ cm}^3 \text{ alloy} &= 1\text{gH}_2 \times \frac{1 \text{ mol H}_2}{2\text{g H}_2} \times \frac{2 \text{ mol Al}}{3 \text{ mol H}_2} \times \frac{27 \text{ g Al}}{1 \text{ mol Al}} \times \frac{100 \text{ g alloy}}{93.7 \text{ g Al}} \times \frac{1 \text{ cm}^3 \text{ alloy}}{2.85 \text{ g alloy}} \\ &= 3.3434 \text{ cm alloy.} \end{aligned}$$

**3. If 470.2 L of NH<sub>3</sub> gas at STP is used in this reaction and percent yield of urea is 79.4 %. What mass of urea, in gram will be obtained?**



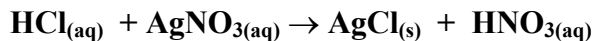
$$\begin{aligned} (?) \text{ g Urea} &= 470.2 \text{ L NH}_3 \times \frac{1 \text{ mol NH}_3}{22.4 \text{ L NH}_3} \times \frac{1 \text{ mol Urea}}{2 \text{ mol NH}_3} \times \frac{60 \text{ g Urea}}{1 \text{ mol Urea}} \\ &= 629.73 \text{ g Urea (Theoretical yield)} \end{aligned}$$

$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100\%$$

$$\text{Actual yield} = \frac{629.73 \text{ g} \times 79.4\%}{100\%} = 500 \text{ g of Urea}$$

4. **34 % by mass HCl<sub>(aq)</sub> has a density of 1.025 g/mL. What volume (mL) of this solution would be required to react with 100mL of 0.265 M, AgNO<sub>3</sub>.**

$$(Cl = 35.5, H = 1)$$



$$(?) \text{ mL HCl}_{(aq)} = 100 \times 10^{-3} \text{ L AgNO}_{3(aq)} \times \frac{0.265 \text{ mol AgNO}_3}{1 \text{ L AgNO}_{3(aq)}} \times \frac{1 \text{ mol HCl}}{1 \text{ mol AgNO}_3} \times$$

$$\frac{36.5 \text{ g HCl}}{1 \text{ mol HCl}} \times \frac{100 \text{ g HCl}_{(aq)}}{34 \text{ g HCl}} \times \frac{1 \text{ mL HCl}_{(aq)}}{1.025 \text{ g HCl}_{(aq)}} = 2.775 \text{ mL HCl}_{(aq)}$$

5. (a) **What volume of solution must be evaporated from 650 mL of 0.0415 M solution to increase the concentration of exactly 0.2 M ?**

$$\begin{aligned} V_1 &= 650 \text{ mL} & V_2 &= ? \\ C_1 &= 0.0415 \text{ M} & C_2 &= 0.2 \text{ M} \\ C_1 V_1 &= C_2 V_2 \\ V_1 &= \frac{650 \text{ mL} \times 0.0415 \text{ M}}{0.2 \text{ M}} = 134.88 \text{ mL} \end{aligned}$$

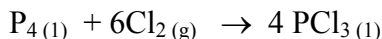
$$\text{volume of water evaporated} = V_1 - V_2 = (650 - 134.88) \text{ mL} = 515.12 \text{ mL}.$$

- (b) **What volume of water (mL) must be added to prepare 250 mL of 0.5 M H<sub>2</sub>SO<sub>4</sub> solution from 6M H<sub>2</sub>SO<sub>4</sub> ?**

$$\begin{aligned} V_1 &= ? & V_2 &= 250 \text{ mL} \\ C_1 &= 6 \text{ M} & C_2 &= 0.5 \text{ M} \\ C_1 V_1 &= C_2 V_2 \\ V_1 &= \frac{250 \text{ mL} \times 0.5 \text{ M}}{6 \text{ M}} = 20.83 \text{ mL} \end{aligned}$$

$$\text{volume of water added} = V_2 - V_1 = (250 - 20.83) \text{ mL} = 229.17 \text{ mL}.$$

6. **What is percent yield, if the reaction of 30 g P<sub>4</sub> and 90 g Cl<sub>2</sub> produces 85.6 g PCl<sub>3</sub> ? (P =31, Cl = 35.5 )**



Assuming that  $P_4$  is the limiting reagent.

$$\begin{aligned} (?) \text{ mol of } PCl_3 &= 30 \text{ g } P_4 \times \frac{1 \text{ mol } P_4}{124 \text{ g } P_4} \times \frac{4 \text{ mol } PCl_3}{1 \text{ mol } P_4} \\ &= 0.9676 \text{ mol } PCl_3 \end{aligned}$$

Assuming that  $Cl_2$  is the limiting reagent.

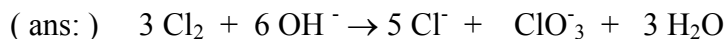
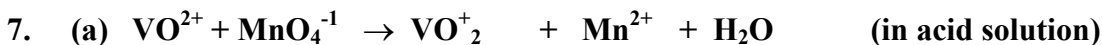
$$\begin{aligned} (?) \text{ mol of } PCl_3 &= 90 \text{ g } Cl_2 \times \frac{1 \text{ mol } Cl_2}{71 \text{ g } Cl_2} \times \frac{4 \text{ mol } PCl_3}{6 \text{ mol } Cl_2} \\ &= 0.8450 \text{ mol } PCl_3 \end{aligned}$$

When the smaller amount ( 0.8450 mol ) of  $PCl_3$  is formed,  $Cl_2$  is completely consumed.

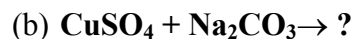
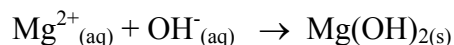
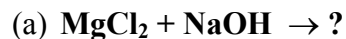
$\therefore Cl_2$  is limiting reagent.

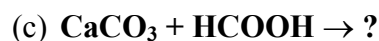
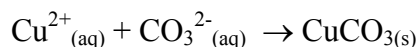
$$(?) \text{ g of } PCl_3 = 0.8450 \text{ mol } PCl_3 \times \frac{138 \text{ g } PCl_3}{1 \text{ mol } PCl_3} = 116.61 \text{ g}$$

$$\begin{aligned} \% \text{ Yield} &= \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\% \\ &= \frac{85.6 \text{ g}}{116.61 \text{ g}} \times 100\% \\ &= 73.4 \% \end{aligned}$$

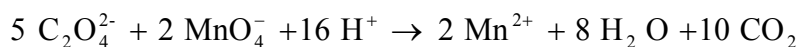
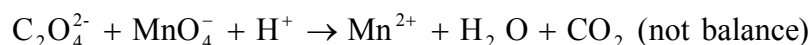


8. Write net ionic equation for the following reactions.





9. **The titration of 50 mL. of a saturated solution of sodium oxalate.  $\text{Na}_2\text{C}_2\text{O}_4$  requires 25.8 mL of 0.0214 M,  $\text{KMnO}_4$ . What mass of  $\text{Na}_2\text{C}_2\text{O}_4$ , in gram, would be present in 1 L of this saturated solution? ( C = 12, O= 16, Na = 23 )**



$$(\text{?}) \text{ g Na}_2\text{C}_2\text{O}_4 = 25.8 \text{ mL KMnO}_4 \times \frac{0.0214 \text{ mol KMnO}_4}{1000 \text{ mL KMnO}_4} \times \frac{5 \text{ mol Na}_2\text{C}_2\text{O}_4}{2 \text{ mol KMnO}_4}$$

$$\times \frac{134 \text{ g Na}_2\text{C}_2\text{O}_4}{1 \text{ mol Na}_2\text{C}_2\text{O}_4} = 0.1849 \text{ g in } 50 \text{ mL}$$

$$(\text{?}) \text{ g/L Na}_2\text{C}_2\text{O}_4 = \frac{0.1849 \text{ g}}{50 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 3.6992 \text{ g/L}$$

## Chapter ( 5 )

### 1. Describe any the assumptions of Kinetic molecular Theory of gases.

- A gas is composed of a very large number of extremely small particles (molecules or atoms) in constant, random, straight-line motion.
- Molecules of a gas are separated by great distances. The gas is mostly empty space.
- Molecules collide with one another and with the walls of their container.
- There are assumed to be no forces between molecules except very briefly during colliding.
- Individual molecules may gain or lose energy as a result of collisions. In a collision of molecules at constant temperature, however, the total energy remains constant.

**2. Explain the following terms:**

**(a) diffusion (b) effusion**

- Diffusion is the migration of molecules of different substances as a result of random molecular motion.
- Effusion is the escape of gas molecules from their container through a tiny hole.

**3. A mixture of 4 g of H<sub>2</sub> and unknown quantity of He(g) is maintain at STP.**

**If 10 g of H<sub>2</sub> is added to the mixture while conditions are maintained at STP.**

**The volume of the gas is double. What mass of He(g) is present in the mixture?**

**(He = 4. H = 1)**

- Let mol of He (initial) = x mol

$$(?) \text{ mol H}_2 \text{ ( initial )} = 4 \text{ g H}_2 \times \frac{1 \text{ mol H}_2}{2 \text{ g H}_2} = 2 \text{ mol H}_2$$

$$(?) \text{ mol H}_2 \text{ ( added )} = 10 \text{ g H}_2 \times \frac{1 \text{ mol H}_2}{2 \text{ g H}_2} = 5 \text{ mol H}_2$$

$$n_1 = (x + 2) \text{ mol} \quad V_1 = V$$

$$n_2 = (x + 7) \text{ mol} \quad V_2 = 2V$$

By Avogadro's theory ( $V \propto n$ )

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

$$\frac{(x+2)}{(x+7)} = \frac{1V}{2V}$$

$$x = 3 \text{ mol (He)}$$

$$(?) \text{ g He} = 3 \text{ mol He} \times \frac{4 \text{ g He}}{1 \text{ mol He}} = 12 \text{ g He}$$

**4. A 1.072 g sample of He(g) is found to occupy a volume of 8.446 L when collected over hexane at 25°C and 738.6 mmHg pressure. Determine the vapour pressure of hexane at 25°C, in mm Hg. ( He = 4, R = 08205 L atom mol<sup>-1</sup> K<sup>-1</sup> ).**

$$T = 25^\circ\text{C} + 273 = 298 \text{ K}$$

$$M = \frac{mRT}{PV}$$

$$P_{\text{He}} = \frac{mRT}{MV} = \frac{1.072 \text{ g} \times 0.08205 \text{ L atm mol}^{-1} \text{ K}^{-1} \times 298 \text{ K}}{4 \text{ g mol}^{-1} \times 8.446 \text{ L}} = 0.7758 \text{ atm}$$

$$= 589.6 \text{ mmHg}$$

$$P_{\text{total}} = P_{\text{He}} + P_{\text{hexane}}$$

$$P_{\text{hexane}} = (738.6 - 589.6) \text{ mmHg} = 149 \text{ mmHg}$$

**5. What mass of sodium azide must be decomposed to produce 1 L of N<sub>2</sub>(g) at 25°C**

and 751 mmHg?  $2\text{NaN}_3(\text{s}) \rightarrow 2\text{Na}(\text{s}) + 3\text{N}_2(\text{g})$

$$T = 25^\circ\text{C} + 273 = 298 \text{ K} \quad P = 751 \text{ mm Hg} \times \frac{1 \text{ atm}}{760 \text{ mm Hg}} = 0.9882 \text{ atm}$$

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{0.9882 \text{ atm} \times 1 \text{ L}}{0.08205 \text{ L atm mol}^{-1} \text{ K}^{-1} \times 298 \text{ K}}$$

$$= 0.0404 \text{ mol N}_2$$

$$(?) \text{ NaN}_3 = 0.0404 \text{ mol N}_2 \times \frac{2 \text{ mol NaN}_3}{3 \text{ mol N}_2} \times \frac{65 \text{ g NaN}_3}{1 \text{ mol NaN}_3} = 1.75 \text{ g}$$

**6. The mass of 1.2 L of a gas sample measured at 35°C and 754 mm Hg is 2.079 g.**

**What is the root mean square velocity of this gas ?**

$$(R = 8.3145 \text{ kg m}^2 \text{ s}^{-2} \text{ mol}^{-1} \text{ K}^{-1}, \quad R = 0.08205 \text{ L atm mol}^{-1} \text{ K}^{-1}).$$

$$T = 35^\circ\text{C} + 273 = 308 \text{ K}$$

$$P = 754 \text{ mm Hg} \times \frac{1 \text{ atm}}{760 \text{ mm Hg}} = 0.9921 \text{ atm}$$

$$M = \frac{mRT}{PV} = \frac{2.079 \text{ g} \times 0.08205 \text{ L atm mol}^{-1} \text{ K}^{-1} \times 308 \text{ K}}{0.9921 \text{ atm} \times 1.2 \text{ L}} = 44.13 \text{ g mol}^{-1}$$

$$U_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.3145 \text{ kg m}^2 \text{ s}^{-2} \text{ mol}^{-1} \text{ K}^{-1} \times 308 \text{ K}}{44.13 \text{ g mol}^{-1}}} = 417.24 \text{ ms}^{-1}$$

7. Suppose we put a cotton plug saturated with HCl solution into one end of 1 meter tube and simultaneously insert a plug saturated with aqueous NH<sub>3</sub> into the other end. How many centimeters from HCl end of the tube will white smoke first form ? ( N = 14, H = 1 , Cl = 35.5 )

Let, distance from HCl = a cm

Molar mass of NH<sub>3</sub> = 17 g / mol

Distance from NH<sub>3</sub> = (100-a) cm

Molar mass of HCl = 36.5 g / mol

$$\frac{\text{distance from HCl}}{\text{distance from NH}_3} = \sqrt{\frac{M_{\text{NH}_3}}{M_{\text{HCl}}}}$$

$$\frac{a}{(100-a)} = \sqrt{\frac{17 \text{ g mol}^{-1}}{36.5 \text{ g mol}^{-1}}} = 0.6824$$

$$a = 40.56 \text{ cm}$$

8. Calculate the pressure exerted by 1 mol of CO<sub>2</sub> (g) confined to a volume of 855 cm<sup>3</sup> at 30°C, Use (a) ideal gas equation and (b) the vander waals equation (c) compare the results and explain.

$$(a = 3.5 \text{ L}^2 \text{ atm mol}^{-2}) \quad (b = 0.0427 \text{ L mol}^{-1})$$

(a) PV = nRT

$$P = \frac{nRT}{V} = 29.0 \text{ atm}$$

(b)  $(P + \frac{n^2}{V^2} a) (V - nb) = nRT$  (vander Waal's equation)

$$P = \frac{nRT}{V - nb} - \frac{n^2 a}{V^2}$$

$$P = 25.8 \text{ atm}$$

(c) The lower pressure calculated by vander Waal's equation is the result of the intermolecular attraction between the real gas molecules.

\*\*\*\*\*

- Describe briefly the meaning of: surface tension, normal boiling point, enthalpy of vaporization, the critical point.
- Equilibrium is established between  $\text{Br}_2$  (l) and  $\text{Br}_2$  (g) at 25°C. A 250 cm<sup>3</sup> sample of the vapor weighs 0.486 g. What is the vapor pressure of bromine at 25°C, in mmHg? ( Br = 79.9 )
- Which of the following molecules can be liquefied at room temperature ( about 25°C ) ?  
 $\text{O}_2$  (  $T_c = 154.8 \text{ K}$  ),  $\text{CO}_2$  (  $T_c = 304.2 \text{ K}$  ).  $\text{SO}_2$  (  $T_c = 431 \text{ K}$  )
- Cyclohexanol used in the manufacture of nylon, has a vapor pressure of 10 mmHg at 56°C and 100 mmHg at 103.7°C. Calculate (a)  $\Delta H_{\text{vap}}$  and (b) normal boiling point. (  $R = 8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$  )
- What are the differences between cohesive forces and adhesive forces?
- What type of intermolecular attractions are present in each of the following molecules?  $\text{NH}_3$ , Ar, HBr,  $\text{CH}_3\text{NH}_2$ , Zn, LiBr,  $\text{CH}_3\text{OH}$ .
- What is meant by the terms instantaneous dipole and induced dipole?
- Which of the following molecules have the higher boiling point?  
 Explain (i) He (or) Ne (ii) n-pentane (or) neo-pentane.
- Which one of the following substance is a liquid at room temperature?  
 Give explanation.  $\text{CH}_3\text{OH}$ ,  $\text{C}_3\text{H}_8$ ,  $\text{N}_2$ , CO
- All electrons in diamond are localized, but that in graphite certain electrons are delocalized.  
 (a) Explain the meaning of localized and delocalized.  
 (b) Which electrons in graphite are delocalized.
- Which member of each pair is more soluble in  $\text{CCl}_4$ . (Give a brief reason)  
 (i)  $\text{CH}_3\text{OH}$  (or)  $\text{CHCl}_3$   
 (ii)  $\text{I}_2$  (or) HI  
 (iii)  $\text{NH}_3$  (or)  $\text{CH}_4$   
 (iv)  $\text{C}_6\text{H}_6$  (or)  $\text{C}_6\text{H}_4(\text{OH})_2$
- Draw the following cubic system and describe the no. of particles (atoms) per unit cell.  
 (i)  $\text{CH}_4$  (or)  $\text{CH}_3\text{OH}$   
 (ii)  $\text{N}_2$  (or)  $\text{NH}_3$

- (iii)  $\text{CaCl}_2$                       (or)  $\text{CCl}_4$   
 (iv)  $\text{CH}_3\text{CH}_2\text{OH}$                 (or)  $\text{CH}_3\text{OCH}_3$

13. Draw the following cubic system and describe the no. of particles (atoms) per unit cell.

- (a) Simple cubic  
 (b) Body – centered cubic  
 (c) Face-centered cubic

14. K crystallize in a BCC unit cell measuring 0.533 nm on the edge. What is the radius of K atom.

15. Ba has a density of  $3.5 \text{ g/cm}^3$  and crystallized in a BCC. Calculate the radius of Ba atom. (  $\text{Ba} = 137$  )

16. The first order reflection of X-rays of wavelength 0.154nm from a nickel crystal occurs at an angle of  $12^\circ 40'$ . What is the distance between the plane atoms diffracting this X- ray beam ?

17. Density of lithium is  $0.534 \text{ g / cm}^3$ . The length of unit cell measures 0.346 nm on an edge. What is the cubic crystal system occupied by lithium? (  $\text{Li} = 7$  )

18. (a) What is meant by the term crystal coordination number.  
 (b) Describe the coordination number of following.

Mg, Cu, Na

19. Explain the structure of ice crystal lattice and why water is denser than ice.

20. Write an account on liquid crystal.

### Chapter ( 7 )

1. Which of the following compounds are mostly ionic and which are mostly covalent.  $\text{KH}$ ,  $\text{H}_2\text{S}$ ,  $\text{SiCl}_4$ ,  $\text{Cr}_2\text{O}_3$

2. (a) Define, Covalent radius, Polar covalent bond.

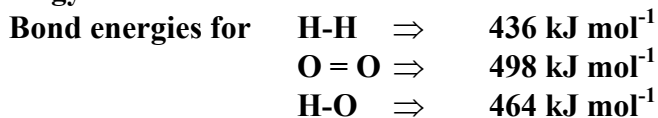
(b) Indicate which of the following bond have the greatest bond length. And shortest bond length.



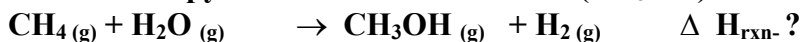
3. Explain why the incomplete octet of  $\text{BF}_3$  is found generally.
4. Although  $\text{PCl}_5$  is a known compound,  $\text{NCl}_5$  is not. What reason can you offer for the failure to observe  $\text{NCl}_5$  ?
5. What is meant by the terms.
  - (i) Valence electron
  - (ii) Resonance
6. Draw the Lewis structure for  
 $\text{N}_2\text{F}_2, \text{HNO}_3, \text{SOCl}_2, \text{F}_3\text{SN}, \text{I}_3^-, \text{CS}_2, \text{PF}_5, \text{XeF}_4, \text{C}_2\text{H}_4$
7. Explain the electron pair repulsion theory with suitable example.
8. Predict the shape of the following molecules and ions.  
 $\text{NH}_2^-, \text{BH}_3, \text{H}_2\text{O}^+, \text{IF}_5, \text{POCl}_3, \text{SiO}_4$
9. Calculate the ionic character of  $\text{H}_2\text{O}$ . It's dipole moment is 1.84 D and bond length is 0.095 nm.  $1 \text{ D} = 3.34 \times 10^{-30} \text{ }^\circ\text{C.m.}$  ( full ionic charge =  $1.6 \times 10^{-19} \text{ C}$ )
10. Discuss the nature of covalent bond in HF molecule by using experimental data. (  $\mu = 1.91 \text{ D}, d = 0.092 \text{ nm}$  )
11. Percent ionic character of HF molecule is 43%. It's dipole moment is  $\mu = 1.9 \text{ D}$ .
12. Estimate the C-H bond energy using a bond energy of  $436 \text{ kJ mol}^{-1}$  for  $\text{H}_2$  and the reaction scheme outlined below.



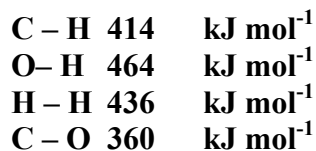
13. Enthalpy of formation of  $\text{H}_2\text{O}_2$  is  $-136 \text{ kJ mol}^{-1}$ , Estimate the O to O single bond energy.



14. Calculate the enthalpy of formation of methanol ( $\text{CH}_3\text{OH}$ )



Bond energies



15. Explain the terms.
  - (i) valence band
  - (ii) conduction band

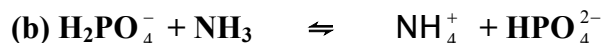
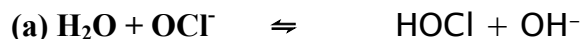
16. How does the electron sea model Explain. ?
- The deformation of metals?
  - Electrical conductivity of metals?
  - Lustrous appearance of metals?

### Chapter 8

- What mass of  $\text{H}_2\text{SO}_4$  is contained in 25g of 15% by mass solution?
- What is the molality of 20% by mass of  $\text{H}_2\text{SO}_4$ ?
- 14.8 M aqueous ammonia solution has a density of 0.898 g/mL.  
What is  $X_{\text{NH}_3}$  in this solution. ( N = 14, H = 1 )
- What is the molarity of 10 % by mass  $\text{H}_2\text{SO}_4$  solution having a density of 1.07 g/ mL?
- What mass of water must be added to 1 kg of 1.12 m  $\text{CH}_3\text{OH}$  (aq:) to reduce the molality to 1.00 m  $\text{CH}_3\text{OH}$  (aq:).
- Define: Henry's Law  
At  $0^\circ\text{C}$  and an  $\text{O}_2$  pressure of 1.00 atm, the aqueous solubility of  $\text{O}_{2(g)}$  is 48.9 mL  $\text{O}_2$  per liter. What is the molarity of  $\text{O}_2$  in a saturated water solution when the  $\text{O}_2$  is under its normal partial pressure in air, 0.2095 atm?
- Calculate the mole fraction of solute in the following aqueous solution.  
(C = 12, H = 1, O = 16, N = 14)  
(a) 13.2 %  $\text{C}_2\text{H}_5\text{OH}$  by mass  
(b) 0.512 m urea  $\text{CO}(\text{NH}_2)_2$
- Calculate the vapor pressure of solution at  $25^\circ\text{C}$  containing 26.9 g of Urea  $\text{CO}(\text{NH}_2)_2$  in 712 g  $\text{H}_2\text{O}$ . (Vapor pressure of water at  $25^\circ\text{C}$  is 23.8 mmHg)  
(N=4, H = 1, O = 16, C = 12)
- An aqueous solution that is 0.205 m urea is formed to boil at  $100.025^\circ\text{C}$ .  
( $K_b = 0.512^\circ\text{C m}^{-1}$ ). Is the actual atmospheric pressure above or below 760 mmHg?
- 1.2 g sample of an unknown covalent compound is dissolved in 50 g of benzene and the solution freezes at  $4.92^\circ\text{C}$ . Determine molar mass of the compound.  
(  $K_f = 5.12^\circ\text{C}$  )
- An osmotic pressure of 3.56 mmHg is measured for 0.288 g of protein in 25 mL of solution at  $25^\circ\text{C}$ . What is the molar mass of the protein?

### Chapter 9

1. Identify acid or base for each of the species in the following forward and reverse reactions.



2. If 535 ml of gaseous HCl, at 26.5°C and 747 mmHg is dissolved in water to prepare 625 mL of solution. What is the pH of this solution.

$$(R = 0.0812 \text{ L atm mol}^{-1} \text{ K}^{-1})$$

3. Calculate the pH of KOH solution that is 3% by mass KOH and has a density of 1.0242 g mL<sup>-1</sup>. (K = 39, O = 16, H = 1)

4. Calculate the pH of a buffer solution containing.

(a) 0.1 M methanoic acid and 0.01 M sodium methanoate. (K<sub>a</sub> = 1.8 × 10<sup>-5</sup>)

(b) 0.15 M acetic acid and 0.5 M CH<sub>3</sub>COONa. (K<sub>a</sub> = 1.7 × 10<sup>-5</sup>)

5. What mass of CH<sub>3</sub>COONa must be dissolved in 0.3L of 0.25 M, CH<sub>3</sub>COOH to produce a solution pH = 5.1.

$$(K_a = 1.74 \times 10^{-5}) \quad (C = 12, H = 1, O = 16, Na = 23)$$

6. Cocaine (C<sub>2</sub>H<sub>22</sub>O<sub>4</sub>N) is an alkaloid, that is soluble in water to the extent of 0.17 g / 100 mL. pH of this solution is 10.08. What is the value of K<sub>b</sub> for cocaine.

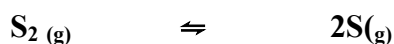
7. The solubility of certain metallic hydroxide M(OH)<sub>3</sub> is 1.0 × 10<sup>-5</sup> mol L<sup>-1</sup>. Calculate the K<sub>sp</sub> of M(OH)<sub>3</sub>.

8. The solubility of silver carbonate at 25°C is 1.16 × 10<sup>-1</sup> M. Calculate the solubility product of that compound.

9. Lead (II) iodide saturated solution, its K<sub>sp</sub> is 7.1 × 10<sup>-9</sup> at 25°C. Calculate the solubility of PbI<sub>2</sub>?

## Chapter 10

1. 0.001 mole of sample of S<sub>2</sub> (g) dissociate in 0.5 L flask at 1000K. At equilibrium, 1 × 10<sup>-11</sup> mole S (g) is present. What is K<sub>c</sub> and K<sub>p</sub>?



2. What is the percent dissociation of N<sub>2</sub>O<sub>4</sub>(g) if 1.5 mole of N<sub>2</sub>O<sub>4</sub>(g) is introduced into a evacuated 2.5 L vessel at 25°C?



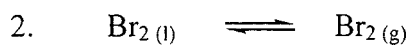
3. The endothermic reaction  $\text{A}(\text{g}) + \text{B}(\text{g}) \rightleftharpoons 2\text{C}(\text{g})$  proceed to the equilibrium condition at  $200^\circ\text{C}$ . Which of the following statements are true?

- (a) If the mixture is transferred to a reaction vessel of twice the volume. The concentration of reactants and products will remain unchanged.
- (b) Addition of B will result in the formation of a greater amount of C(g).
- (c) Lowering the reaction temperature to  $100^\circ\text{C}$  will result in the formation of a greater amount of C (g).

4. 5 g  $\text{PCl}_5$  is placed in a 250 mL flask and it is heated to  $300^\circ\text{C}$ , where the following equilibrium establish.  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$

The quantity of  $\text{Cl}_2$  present at equilibrium is found to be 0.25g. What is the value of  $K_c$  for the dissociation reaction at  $300^\circ\text{C}$ ? ( $P = 31$ ,  $\text{Cl} = 35.5$ )

5. Describe the relationship between  $K_c$  and  $K_p$ .

**Chapter 6**

$$V = 250 \text{ cm}^3 = 0.25 \text{ L}$$

$$m = 0.486 \text{ g}$$

$$M = 79.9 \text{ g/mol}$$

$$T = 273 + 25^\circ\text{C} = 298 \text{ K}$$

$$PV = \frac{m}{M}RT$$

$$P = \frac{mRT}{MV} = \frac{0.486 \text{ g} \times 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1} \times 298 \text{ K}}{79.9 \text{ g/mol} \times 0.25 \text{ L}}$$

$$= 0.5949 \text{ atm}$$

$$= 452.718 \text{ mm Hg}$$

3. A gas can be liquefied only at temperature below its critical temperature,  $T_c$ .

$$\text{Room temp} = 25^\circ\text{C} = 298 \text{ K}$$

$\text{O}_2$  ( $T_c = 154.8 \text{ K}$ ) cannot be liquefied because room temperature is above  $T_c$ .

$\text{CO}_2$  ( $T_c = 304.2 \text{ K}$ ) can be liquefied because room temperature is below  $T_c$ .

4. (a)  $P_1 = 10 \text{ mm Hg}$   $T_1 = 56^\circ\text{C} + 273 = 329 \text{ K}$   
 $P_2 = 100 \text{ mm Hg}$   $T_2 = 103.7^\circ\text{C} + 273 = 376.7 \text{ K}$   
 $R = 8.3145 \text{ Jmol}^{-1}\text{K}^{-1}$   $\Delta H_{\text{vap}} = ?$

$$\ln \frac{P_2}{P_1} = \frac{\Delta H_{\text{vap}}}{R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$\ln \frac{100}{10} = \frac{\Delta H_{\text{vap}}}{R} (3.849 \times 10^{-4})$$

$$2.3025 = \frac{\Delta H_{\text{vap}}}{8.3145 \text{ Jmol}^{-1}\text{K}^{-1}} (3.849 \times 10^{-4}) \text{ K}^{-1}$$

$$\Delta H_{\text{vap}} = 49.7397 \text{ kJmol}^{-1}$$

$$(b) P_1 = 10 \text{ mm Hg} \quad T_1 = 56^\circ\text{C} + 273 = 329 \text{ K}$$

$$P_2 = 760 \text{ mm Hg} \quad T_2 = ?$$

(for normal boiling point)

$$R = 8.3145 \text{ Jmol}^{-1}\text{K}^{-1}$$

$$\Delta H_{\text{vap}} = 49739.7 \text{ Jmol}^{-1}$$

$$\ln \frac{760}{10} = \frac{49739.7 \text{ Jmol}^{-1}}{8.3145 \text{ Jmol}^{-1}\text{K}^{-1}} \left( \frac{1}{329} - \frac{1}{T_2} \right) \text{K}^{-1}$$

$$4.33 = 5982.3 \text{ K} \left( 3.849 \times 10^{-3} - \frac{1}{T_2} \right)$$

$$T_2 = 431.84 \text{ K}$$

$$T_2 = 158.8 \text{ K (normal boiling point of cyclohexanol)}$$

6.  $\text{NH}_3$  = Hydrogen bond + London forces

Ar = London force only

HBr = dipole-dipole attraction + London forces

Zn = Metallic bond

LiBr = Electrostatic attraction

8. (i) He (or) Ne

- Both substances are non-polar.
- Ne has higher molecular mass and greater polarizability.
- $\therefore$  Ne has stronger dispersion forces and higher boiling point than He.

(ii) n-pentane neo-pentane

Elongated molecule

Small, compact, symmetrical molecule

Electrons in elongated molecules are more easily displaced than symmetrical molecule and more polarizable and have greater dispersion forces.  $\therefore$  n-pentane has higher boiling point than neo-pentane.

9.  $\text{CH}_3\text{OH}$  = Hydrogen bond and dipole-dipole attraction  
 $\text{N}_2$ ,  $\text{C}_3\text{H}_8$  = London force  
 $\text{CO}$  = dipole-dipole attraction  
 More stronger intermolecular attraction corresponds to liquid state at room temperature.
10. See Pg.61, 62
11. (i)  $\text{CH}_3\text{OH}$  is more polar.  
 $\text{CHCl}_3$ , less polar, will be soluble in non-polar  $\text{CCl}_4$ .  
 (ii)  $\text{I}_2$  is non-polar that is similar to  $\text{CCl}_4$ .  
 $\text{I}_2$  is more soluble in non-polar  $\text{I}_2$  is  $\text{CCl}_4$ .  
 (iii)  $\text{NH}_3$  is polar.  $\text{CH}_4$  is more soluble likely to non-polar  $\text{CCl}_4$ .  
 (iv)  $\text{C}_6\text{H}_4(\text{OH})_2$  is polar.  $\text{C}_6\text{H}_6$  is more soluble because it is non-polar likely to  $\text{CCl}_4$ .
12. (i)  $\text{CH}_3\text{OH}$  is more soluble because it can form hydrogen bond with water.  
 $\text{CH}_4$  is non-polar that is unable to form hydrogen bond with water.  
 (ii)  $\text{NH}_3$  more soluble because it can form hydrogen bond with water.  
 $\text{N}_2$  is non-polar that is unable to form hydrogen bond with water.  
 (iii)  $\text{CaCl}_2$  is more soluble due to it's ionic dipole.  
 $\text{CCl}_4$  is non-polar and cannot dissolve in water.  
 (iv)  $\text{CH}_3\text{CH}_2\text{OH}$  is more soluble because it can form hydrogen bond with water.  
 (v)  $\text{CH}_3\text{COCH}_3$  is non-polar that is unable to form hydrogen bond with water.
13. See pg.65.
14. K is BCC unit cell.  
 For BCC  $4r = 1\sqrt{3}$   

$$r = \frac{0.533 \times \sqrt{3}}{4} = 0.2308 \text{ nm}$$

$$15. \quad \text{cm}^3/\text{unit cell} = \frac{1 \text{ cm}^3}{3.5 \text{ g}} \times \frac{137 \text{ g}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}} \times \frac{2 \text{ atoms}}{1 \text{ unit cell}}$$

$$= 1.3 \times 10^{22} \text{ cm}^3/\text{unit cell}$$

$$\text{Length of the unit cell} = (1.3 \times 10^{22} \text{ cm}^3)^{1/3}$$

$$= 5.066 \times 10^{-8} \text{ cm}$$

$$= 0.5066 \text{ nm}$$

$$\text{For BCC} \quad 4r = 1\sqrt{3}$$

$$r = \frac{0.5066 \times \sqrt{3}}{4} = 0.2194 \text{ nm}$$

$$16. \quad \lambda = 0.154 \text{ nm} \qquad n\lambda = 2d \sin\theta$$

$$\theta = 12^\circ 40'$$

$$d = ? \qquad d = \frac{n\lambda}{2 \sin\theta}$$

$$= \frac{0.154 \text{ nm} \times 1}{2 \sin 12^\circ 40'}$$

$$1 \text{ st : order} = n = 1 \qquad = 0.351 \text{ nm}$$

$$17. \quad \text{Vol: of unit cell} = (0.346 \text{ nm})^3 = (0.346 \text{ nm} \times 10^{-7} \text{ cm})^3$$

$$= 4.142 \times 10^{-23} \text{ cm}^3/\text{unit cell}$$

$$(\text{?}) \text{ atoms/unit cell} = \frac{6.023 \times 10^{23} \text{ atoms}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{7 \text{ g}} \times \frac{0.534 \text{ g}}{1 \text{ cm}^3}$$

$$= 1.9 \text{ atoms} \approx 2 \text{ atoms/unit cell}$$

$\therefore$  Li is body-centered cubic system.

18. Coordination number

Mg = H.C.P ----- 12

Cu = F.C.C ----- 12

Na = B.C.C ----- 8

**Chapter 7**

9.

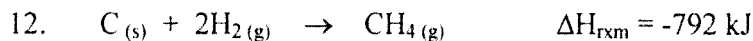
$$\mu = 1.84 \text{ D} \times \frac{3.34 \times 10^{-30} \text{ C.m}}{1 \text{ D}} = 6.1456 \times 10^{-30} \text{ C.m}$$

$$d = 0.095 \text{ nm} \times 10^{-9} \text{ m}$$

$$\delta = \frac{\mu}{d} = \frac{6.1456 \times 10^{-30} \text{ C.m}}{0.095 \text{ nm} \times 10^{-9} \text{ m}} = 6.469 \times 10^{-20} \text{ C}$$

$$\% \text{ ionic character} = \frac{6.469 \times 10^{-20} \text{ C}}{1.6 \times 10^{-19} \text{ C}} \times 100 = 40.43\%$$

Problem no. 10 and 11 are the same as no.9.



$$\Delta H_{\text{rxn}} = \sum \Delta H_{(\text{reactants})} - \sum \Delta H_{(\text{products})}$$

$$-792 \text{ kJ} = 2\Delta\Delta_{\text{H}_2} - \Delta H_{\text{CH}_4}$$

$$-792 \text{ kJ} = 2\Delta\Delta_{(\text{H-H})} - 4\Delta\Delta_{(\text{C-H})}$$

$$-792 \text{ kJ} = (2 \times 436) - 4\Delta\Delta_{(\text{C-H})}$$

$$4\Delta\Delta_{(\text{C-H})} = 1664$$

$$4\Delta\Delta_{(\text{C-H})} = 416 \text{ kJ mol}^{-1}$$

(C-H) bond energy is 416 kJ/mol

Problem no. 13 and 14 are the same as no.12.

**Chapter 8**

May be for self-study of hybridized configurations.

Chapter 9

$$1. \quad (?) \text{ mass H}_2\text{SO}_4 = \frac{\text{mass \% H}_2\text{SO}_4 \times \text{mass of solution}}{100}$$

$$= \frac{15 \times 25}{100} = 3.75 \text{ g}$$

$$2. \quad (?) \text{ mole H}_2\text{SO}_4 = 20 \text{ g} \times \frac{1 \text{ mol}}{100 \text{ g}} = 0.2041 \text{ mol}$$

$$(?) \text{ kg H}_2\text{O} = 80 \times 10^{-3} \text{ kg H}_2\text{O}$$

$$\text{Molality} = \frac{\text{mole of solute}}{\text{kg of solvent}} = \frac{0.2041 \text{ mole}}{0.08 \text{ kg}} = 2.55 \text{ m}$$

$$(?) \text{ g of NH}_3 = 14.8 \text{ mol NH}_3 \times \frac{17 \text{ g}}{1 \text{ L of NH}_3} = 251.6 \text{ g}$$

$$3. \quad (?) \text{ g of NH}_{3(\text{aq})} = 1 \text{ L NH}_{3(\text{aq})} \times \frac{0.898 \text{ g NH}_{3(\text{aq})}}{10^{-3} \text{ L of NH}_{3(\text{aq})}} = 898 \text{ g NH}_{3(\text{aq})}$$

$$(?) \text{ g of water} = (898 - 251.6) \text{ g} = 646.4 \text{ g H}_2\text{O}$$

$$(?) \text{ mol of water} = 646.4 \text{ g H}_2\text{O} \times \frac{1 \text{ mol}}{18 \text{ g H}_2\text{O}} = 35.91 \text{ mol H}_2\text{O}$$

$$X_{\text{NH}_3} = \frac{14.8}{14.8 + 35.91} = 0.2918$$

$$4. \quad (?) \text{ M H}_2\text{SO}_4 = \frac{1 \text{ mol H}_2\text{SO}_4}{98 \text{ g H}_2\text{SO}_4} \times \frac{10 \text{ g H}_2\text{SO}_4}{100 \text{ g H}_2\text{SO}_{4(\text{aq})}} \times \frac{1.079 \text{ g H}_2\text{SO}_{4(\text{aq})}}{10^{-3} \text{ L H}_2\text{SO}_{4(\text{aq})}}$$

$$= 1.092 \text{ mol/L} = 1.092 \text{ M}$$

$$5. \quad \underline{1.12 \text{ M, CH}_3\text{OH}_{(\text{aq})}, 1 \text{ kg (Before dilution)}}$$

$$(?) \text{ g CH}_3\text{OH} = 1.12 \text{ mol} \times \frac{32 \text{ g}}{1 \text{ mol}} = 35.84 \text{ g CH}_3\text{OH}$$

$$(?) \text{ g CH}_3\text{OH}_{(\text{aq})} = 35.84 + 1000 \text{ g H}_2\text{O} = 1035.84 \text{ g}$$

$$(?) \text{ g H}_2\text{O in 1 kg of given solution} = 1000 \text{ g CH}_3\text{OH}_{(\text{aq})} \times \frac{1000 \text{ g H}_2\text{O}}{1035.84 \text{ g CH}_3\text{OH}_{(\text{aq})}}$$

$$= 965.4 \text{ g H}_2\text{O}$$

$$(?) \text{ g CH}_3\text{OH} = 000 \text{ g CH}_3\text{OH}_{(aq)} \times \frac{3.84 \text{ g CH}_3\text{OH}}{03.84 \text{ g CH}_3\text{OH}_{(aq)}} = 34.6 \text{ g CH}_3\text{OH}$$

$$\begin{aligned} (?) \text{ g H}_2\text{O after diluton} &= 34.6 \text{ g CH}_3\text{OH}_{(aq)} \times \frac{\text{mol}}{32 \text{ g}} \times \frac{000 \text{ g H}_2\text{O}}{\text{mol}} \\ &= 08.2 \text{ g H}_2\text{O} \end{aligned}$$

$$(?) \text{ g H}_2\text{O added} = 08.2 - 96.4 = .8 \text{ g of H}_2\text{O}$$

6.  $C_1 = 48.9 \text{ mL O}_2 \text{ L}^{-1}$

$C_2 = ?$

$P_1 = 1 \text{ atm}$

$P_2 = 0.02095 \text{ atm}$

By Henry's law,

$$\frac{C_1}{P_1} = \frac{C_2}{P_2}$$

$$C_2 = \frac{48.9 \times 0.20}{1} = 0.24 \text{ mL O}_2 \text{ L}^{-1}$$

7. (a)

$$(?) \text{ mol C}_2\text{H}_5\text{OH} = 13.2 \text{ g} \times \frac{1 \text{ mol C}_2\text{H}_5\text{OH}}{46 \text{ g C}_2\text{H}_5\text{OH}} = 0.2869 \text{ mol}$$

$$(?) \text{ mol H}_2\text{O} = 86.8 \text{ g} \times \frac{1 \text{ mol H}_2\text{O}}{18 \text{ g H}_2\text{O}} = 4.82 \text{ mol}$$

$$X_{\text{C}_2\text{H}_5\text{OH}} = \frac{n_{\text{C}_2\text{H}_5\text{OH}}}{n_{\text{C}_2\text{H}_5\text{OH}} + n_{\text{H}_2\text{O}}} = 0.0562$$

(b)  $(?) \text{ mol H}_2\text{O} = 1000 \text{ g H}_2\text{O} \times \frac{1 \text{ mol}}{18 \text{ g}} = 55.56 \text{ mol H}_2\text{O}$

$$X_{\text{CO(NH}_2)_2} = \frac{0.512}{0.512 + 55.56} = 9.13 \times 10^{-3}$$

8.  $(?) \text{ mol CO(NH}_2)_2 = 26.9 \text{ g} \times \frac{1 \text{ mol}}{60 \text{ g}} = 0.4483 \text{ mol}$

$$(?) \text{ mol H}_2\text{O} = 712 \text{ g} \times \frac{1 \text{ mol}}{18 \text{ g}} = 39.55 \text{ mol}$$

$$X_{\text{H}_2\text{O}} = \frac{n_{\text{H}_2\text{O}}}{n_{\text{CO(NH}_2)_2} + n_{\text{H}_2\text{O}}} = 0.988$$

$$9. \quad \Delta T_b = K_b m$$

$$= 0.512^\circ\text{C m}^{-1} \times 0.205 \text{ m} = 0.10496^\circ\text{C}$$

$$\Delta T_b = T_{\text{solution}} - T_{\text{solvent}}$$

$$= 0.10496^\circ\text{C} - 100^\circ\text{C} = 100.10496^\circ\text{C}$$

The solution is formed to be boiled at  $100.025^\circ\text{C}$  that is less than calculated value.  $\therefore$  Actual atmospheric pressure is less than 760 mm Hg.

$$10. \quad \text{Mass \%} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$$

$$(?) \text{ mol of } \text{C}_2\text{H}_{12}\text{O}_6 = 30 \text{ g} \times \frac{1 \text{ mol}}{180 \text{ g}} = 0.167 \text{ mol}$$

$$m = \frac{0.167 \text{ mol}}{70 \times 10^{-3} \text{ g}} = 2.386 \text{ m}$$

$$\Delta T_b = K_b m$$

$$= 0.512^\circ\text{C m}^{-1} \times 2.386 \text{ m} = 1.22^\circ\text{C}$$

$$\Delta T_b = T_{\text{solution}} - T_{\text{solvent}}$$

$$= 1.22^\circ\text{C} - 100^\circ\text{C} = 101.22^\circ\text{C}$$

11. Solutions for the problem are

$\Delta T_f = 0.56^\circ\text{C}$ ,  $m = 0.1093\text{m}$ , and molecular wt: = 220 amu respectively.

$$13. \quad \pi = \frac{3.56}{760} \text{ atm} = 4.68 \times 10^{-3} \text{ atm}$$

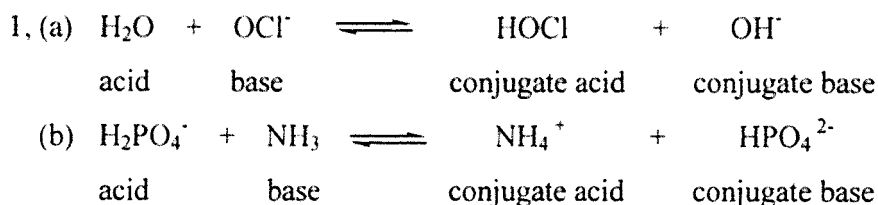
$$T = 25^\circ\text{C} + 273 = 298 \text{ K}$$

$$\pi V = nRT$$

$$n = \frac{\pi V}{RT} = \frac{4.68 \times 10^{-3} \text{ atm} \times 25 \times 10^{-3} \text{ L}}{0.0821 \text{ L atm mol}^{-1} \text{K}^{-1} \times 298 \text{ K}}$$

$$= 4.786 \times 10^{-6} \text{ mol}$$

$$\text{Molar mass of protein} = \frac{0.288 \text{ g}}{4.786 \times 10^{-6} \text{ mol}} = 60175.5 \text{ g/mol}$$

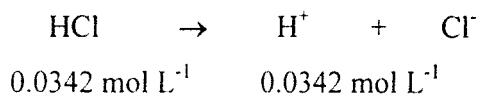
**Chapter 10**

2.  $PV = nRT$

$$n = \frac{PV}{RT} = \frac{0.9829 \text{ atm} \times 535 \times 10^{-3} \text{ L}}{0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1} \times 299.5 \text{ K}}$$

$$= 0.0214 \text{ mol N}_2$$

$$M = \frac{0.0214 \text{ mol}}{625 \times 10^{-3} \text{ L}} = 0.0342 \text{ mol L}^{-1}$$

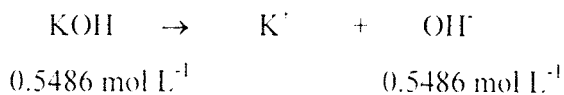


$$[\text{H}^+] = 0.0342 \text{ mol L}^{-1}$$

$$-\log [\text{H}^+] = -\log (0.0342)$$

$$\text{pH} = 1.47$$

3.  $(?) [\text{KOH}] = \frac{1 \text{ mol KOH}}{56 \text{ g KOH}} \times \frac{3 \text{ g KOH}}{100 \text{ g KOH}_{(\text{aq})}} \times \frac{1.0242 \text{ g KOH}_{(\text{aq})}}{0.001 \text{ L KOH}_{(\text{aq})}} = 0.5486 \text{ mol L}^{-1}$



$$[\text{OH}^-] = 0.5486 \text{ mol L}^{-1}$$

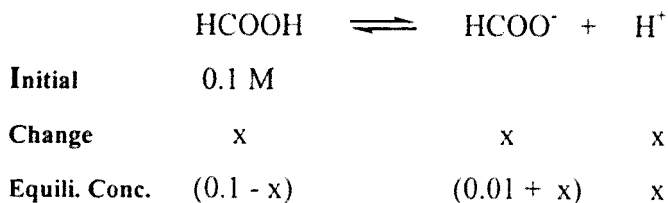
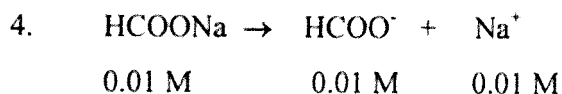
$$-\log [\text{OH}^-] = -\log (0.5486)$$

$$\text{pOH} = 0.2607$$

$$\text{pH} = 14 - \text{pOH}$$

$$= 14 - 0.2607$$

$$= 13.7393$$



$$K_a = \frac{[\text{HCOO}^-][\text{H}^+]}{[\text{HCOOH}]}$$

$$1.8 \times 10^{-5} = \frac{(0.01 + x)(x)}{(0.1 - x)}$$

Assuming that x is very small, compared to 0.1.

$$\frac{0.01x}{0.1} = 1.8 \times 10^{-5}$$

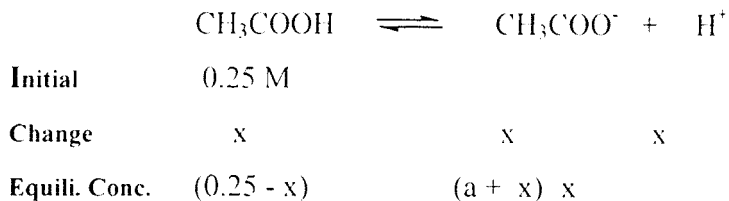
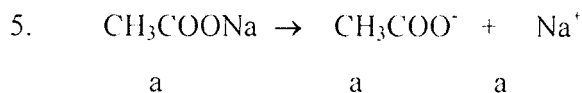
$$x = [\text{H}^+] = 1.8 \times 10^{-4}$$

$$\text{pH} = 3.74$$

(b) To be solved likely to the way as no. (a).

$$\text{pH} = 5.1$$

$$[\text{H}^+] = 7.94 \times 10^{-6} \text{ M}$$



$$K_a = \frac{[\text{HCOO}^-][\text{H}^+]}{[\text{HCOOH}]}$$

$$1.8 \times 10^{-5} = \frac{(a + x)(x)}{(0.25 - x)}$$

Assuming that  $x$  is very small, compared to 0.25.

$$a = 0.5476 \text{ M} = [\text{CH}_3\text{COO}^-] = [\text{CH}_3\text{COONa}]$$

$$\begin{aligned} (?) \text{ g CH}_3\text{COONa} &= 0.3 \text{ L} \times \frac{0.5476 \text{ mol}}{1 \text{ L}} \times \frac{82 \text{ g}}{1 \text{ mol}} \\ &= 13.47 \text{ g CH}_3\text{COONa} \end{aligned}$$

6.  $\text{pH} = 10.08$

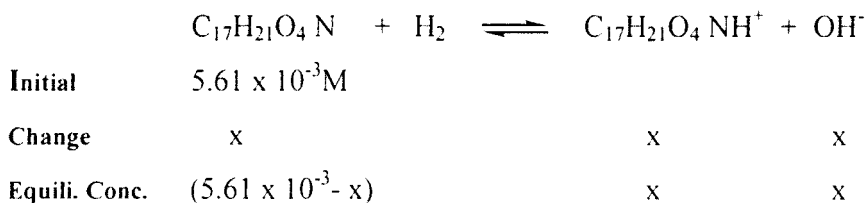
$$\therefore \text{pOH} = 3.92$$

$$\therefore [\text{OH}^-] = 10^{-\text{pOH}}$$

$$= 10^{-3.92}$$

$$= 1.2 \times 10^{-4} \text{ mol L}^{-1}$$

$$\begin{aligned} [\text{cocaine}] = [\text{C}_{17}\text{H}_{21}\text{O}_4\text{N}] &= \frac{0.17 \text{ g}}{0.1 \text{ L}} \times \frac{0.1 \text{ mol}}{303 \text{ g}} \\ &= 5.61 \times 10^{-3} \text{ M} \end{aligned}$$



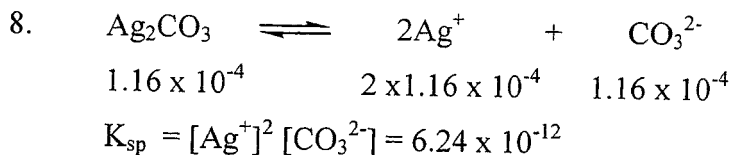
$$\begin{aligned} K_b &= \frac{[\text{C}_{17}\text{H}_{21}\text{O}_4\text{NH}^+][\text{OH}^-]}{[\text{C}_{17}\text{H}_{21}\text{O}_4\text{N}][\text{H}_2\text{O}]} \\ &= \frac{x^2}{(5.61 \times 10^{-3} - x)} \end{aligned}$$

Assuming that  $x$  is very small, compared to 0.1.

$$K_b = \frac{(1.2 \times 10^{-4})^2}{(5.61 \times 10^{-3})} = 2.57 \times 10^{-6}$$

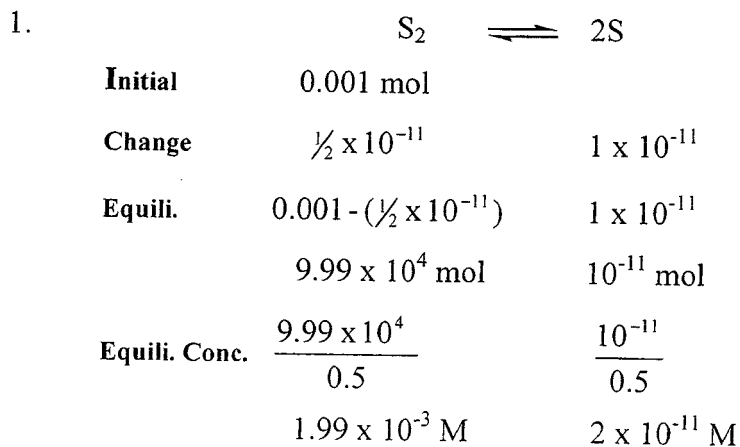


$$\begin{aligned} K_{sp} &= [\text{M}^{3+}][3\text{OH}^-]^3 \\ &= (10^{-5} \times 3 \times 10^{-5})^3 \\ &= 2.7 \times 10^{-19} \end{aligned}$$



9. To be solved in such a way as no.7, and 8.

### Chapter 11



$$K_C = \frac{[\text{S}]^2}{[\text{S}_2]} = \frac{(2 \times 10^{-11})^2}{1.99 \times 10^{-3}} = 2 \times 10^{-19}$$

$$K_P = K_C (RT)^{\Delta n} \qquad \Delta n = (2 - 1) = 1$$

$$= 2 \times 10^{-19} \times (0.0821 \times 1000)^1$$

$$= 1.65 \times 10^{-17}$$

2. In being so, like the same as no.1.
3. (a) and (b) are true.
4. May be to calculate like as no.1 and also as no.2.
5. See pg: 125 ( **Relation bet:  $K_P$  and  $K_C$**  )

# **SOLUTIONS**

**FOR**

**E.Ph 01011**

## **ENGINEERING PHYSICS**

- \* **Must Know**
- \*\* **Should Know**
- \*\*\* **Could Know**

**NOTE:** Respective examples in each chapter must be taken as **MUST KNOW**.

## CHAPTER I

Question :

\*  
1.1 What do you understand by the term "dimension of a physical quantity"?

Solution:

Dimension of a physical quantity is the power which is needed to put on base quantities.

\*  
1.2 Write down the dimensional notations for the following quantities :

(a) momentum      (b) the constant of gravitation  $G$   
(c) potential energy (d) torque or moment of force .

Solution:

$$\begin{aligned} \text{(a) momentum} &= \text{mass} \times \text{velocity} \\ &= \text{mass} \times \frac{\text{length}}{\text{time}} = [MLT^{-1}] \end{aligned}$$

$$\begin{aligned} \text{(b) force} &= G \frac{\text{mass} \times \text{mass}}{(\text{distance})^2} \quad (\text{Universal gravitational law}) \\ \therefore G &= \frac{\text{force} \times (\text{distance})^2}{(\text{mass})^2} \end{aligned}$$

$$\begin{aligned} \text{Since force} &= \text{mass} \times \frac{\text{length}}{(\text{time})^2} \\ G &= \frac{\text{mass} \times \text{length}}{(\text{time})^2} \times \frac{(\text{distance})^2}{(\text{mass})^2} \\ &= [M^{-1}L^3T^{-2}] \end{aligned}$$

$$\begin{aligned} \text{(c) potential energy} &= \text{mass} \times \text{acceleration due to gravity} \times \text{height} \\ &= [MLT^{-2}L] \\ &= [ML^2T^{-2}] \end{aligned}$$

$$\begin{aligned}
 \text{(d) torque or moment of force} &= \text{force} \times \text{perpendicular distance} \\
 &= [MLT^{-2}][L] \\
 &= [ML^2T^{-2}]
 \end{aligned}$$

\*  
1.3 State the principle of dimensional homogeneity.

Solution:

A physically correct equation must have the same dimensions (or units) on both the right-hand side (RHS) and the left-hand side (LHS) of the equation.

\*  
1.4 What are the fundamental quantities? How many are there, and what are they?

Solution:

Fundamental quantities are quantities which are used to describe other physical quantities.

There are seven fundamental quantities and they are:

- (i) Length
- (ii) Mass
- (iii) Time
- (iv) Electric current
- (v) Temperature
- (vi) Amount of substance
- (vii) Luminous intensity

\*  
1.5 What are derived quantities?

Solution:

Derived quantities are physical quantities, which can be described in terms of fundamental quantities.

\*  
1.6 In the statement "The mass of a block wood is 2 kilogram", what does kilogram stand for and what does kilogram stand for and what does 2 stand for.

Solution:

Kilogram stand for unit and 2 stand for numerical magnitude.

\* 1.7. Is mass a fundamental physical quantity (or) derived quantity? Give reason.

Solution:

Yes, mass is a fundamental physical quantity. Other physical quantities such as momentum, force and kinetic energy can be described in terms of mass as shown below.

$$\text{momentum} = \text{mass} \times \text{velocity}$$

$$\text{force} = \text{mass} \times \text{acceleration}$$

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2$$

\* 1.8. Is force a fundamental quantity? Give reason.

Solution:

No, force is not a fundamental quantity. It is a derived quantity. Force can be described by fundamental quantities, mass, length and time as shown below.

$$\text{force} = \text{mass} \times \text{acceleration}$$

$$= \text{mass} \times \frac{\text{length}}{(\text{time})^2}$$