You should try to answer on your own before seeking H-E-L-P-S.

TOPIC opening ....

Question 1

(a) Define *density*. [1]

(b) Liquid of density ρ fills a container to a depth h, as illustrated in Fig. 3.1.

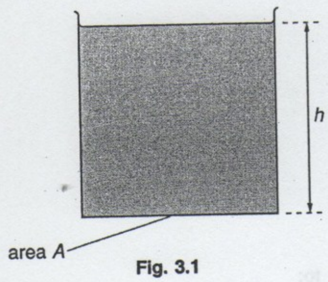

Fig. 3.1

The container has vertical sides and a base of area A.

(i) State, in terms of A, h and ρ, the mass of liquid in the container. [1]

(ii) Hence derive an expression for the pressure p exerted by the liquid on the base of the container. Explain your working. [2]

(c) The density of liquid water is 1.0 g cm^{-3}. The density of water vapour at atmospheric pressure is approximately $\frac{1}{1600}$ g cm^{-3}.

Determine the ratio

(i) $\frac{\text{volume of water vapour}}{\text{volume of equal mass of liquid water}}$, [1]

(ii) $\frac{\text{mean separation of molecules in water vapour}}{\text{mean separation of molecules in liquid water}}$. [2]

(d) State the evidence for

(i) the molecules in solids and liquids having approximately the same separation, [1]

(ii) strong rigid forces between molecules in solids. [2]

{J07/P2/Q3}

Suggested Solution:

(a) Mass per unit volume is called density.

(b) (i) $m = \rho hA$

(ii) Pressure $= \frac{\text{Force}}{\text{Area}}$

Force on base = weight of liquid

$= mg$

$= \rho hAg$

So $p = \frac{\rho hAg}{A} \Rightarrow p = h\rho g$

(b) (i) Note that:
$m = \rho v$
$m = \rho Ah$, as volume = area x height

Learning CORNER

(c) (i) $\frac{V_{vapour}}{V_{liquid}} = \frac{\frac{m}{\rho_{vapour}}}{\frac{m}{\rho_{liquid}}} = \frac{\rho_{liquid}}{\rho_{vapour}}$

$= \frac{1.0}{\frac{1}{1600}}$

$= 1600 : 1$

$\therefore$ ratio $= 1600 : 1$

(ii) $\frac{d_v}{d_l} = \left(\frac{\rho_l}{\rho_v}\right)^{\frac{1}{3}} = \left(\frac{1}{\frac{1}{1600}}\right)^{\frac{1}{3}} = (1600)^{\frac{1}{3}} = 11.7$

$\therefore$ ratio $= 11.7$

(d) (i) Density of solids and liquids are equal.

(ii) strong: volume is fixed

rigid: does not flow and retain shape

Question 2

(a) (i) State one **similarity** between the processes of evaporation and boiling. [1]

(ii) State two **differences** between the processes of evaporation and boiling. [4]

(b) Titanium metal has a density of 4.5 g cm^{-3}.

A cube of titanium of mass 48 g contains 6.0×10^{23} atoms.

(i) Calculate the volume of the cube. [1]

(ii) Estimate

1. the volume occupied by each atom in the cube, [1]
2. the separation of the atoms in the cube. [1]

[N09/P22/Q2]

Suggested Solution:

(a) (i) In both these processes, a liquid changes to vapour state.

(ii) 1. Evaporation occurs at the surface of liquid. Boiling occurs throughout the liquid.

2. Evaporation occurs at any temperature. Boiling occurs at one temperature.

(b) (i) $\rho = \frac{m}{V}$

$4.5 = \frac{48}{V} \Rightarrow V = 10.7\ cm^3$

(ii) 1. Total volume = (no. of atoms in a cube)(volume of one atom)

$10.7 = (6.0 \times 10^{23})V$

$V = \frac{10.7}{6.0 \times 10^{23}} = 1.78 \times 10^{-23}\ cm^3$

2. Volume $= (\text{separation})^3$

i.e $V = d^3$

$d = (1.78 \times 10^{-23})^{\frac{1}{3}} = 2.61 \times 10^{-8}$ cm

(c) $m = \rho v \Rightarrow v = \frac{m}{\rho}$

(i) Liquid water expands when it evaporates and so answer must be greater than 1.

(ii) The mean separation between two molecules is equal to its size. If 'd' is the separation, then the volume of the molecule (assuming spherical) is given by

$V = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3$

$V \propto d^3$

the density of molecule

$\rho = \frac{1}{V} \Rightarrow \rho \propto \frac{1}{d^3}$ is then inversely proportional to the mean separation 'd' raised to the power of three.

(a) (i) Thermal energy need to be supplied to maintain constant temperature during both processes.

(ii) Other differences are:

- The temperature of liquid during evaporation decreases.
  The temperature of liquid during boiling remain constant.
- No bubbles are formed during evaporation.
  Bubbles are formed during boiling.

(b) (ii) 2. The mean separation between two atoms is equal to its size. If 'd' is the separation, then the volume of an atom, $V \propto d^3$