1 atm = 101325 Pa = 760 mmHg = 760 torr	1 L = 1 dm^3 = 1×10^{-3} m^3	The molar volume of an ideal gas at s.t.p. is 22.4 dm^3 mol^{-1}	$pV = nRT$
density of H_2O = 1.0 g cm^{-3} at 25°C	R = 8.31 J mol^{-1} K^{-1} = 8.314 m^3 Pa mol^{-1} K^{-1} 0.0821 L atm mol^{-1} K^{-1}	Avogadro's constant = 6.02×10^{23} mol^{-1}.	

SECTION A: MULTIPLE CHOICE QUESTIONS

Answer ALL ***questions in this section on the*** *ANSWER SHEET PROVIDED* ***according to the instructions on it. There is one mark for each of the questions on this section.***

RAM of C = 12.0, Cu = 63.5, K = 39.1, H = 1.0, O = 16.0, Mg = 24.3, S = 32.1, Ag = 107.9, Na = 23.0, Cl = 35.5, N = 14.0

1) If the relative molecular mass of a compound is 46, then
   A One mole of the compound weighs 46 g.
   B One molecule of the compound weighs 46 g.
   C One mole of the compound contains $46\times6\times10^{23}$ molecules.
   D The empirical formula is the same as the molecular formula.
   E One molecule of the compound weighs $46\times6\times10^{23}$ g.

2) A mixture of 5.0 mol of neon and 3.0 mol of oxygen exert a pressure of 560 mmHg. If the oxygen alone filled the same container, its pressure would be
   A 70 mmHg
   B 210 mmHg
   C 350 mmHg
   D 560 mmHg
   E 1493 mmHg

3) A gas is 1.64 times as dense as nitrogen at the same temperature and pressure. What is the relative molecular mass of the gas?
   A 14
   B 17
   C 23
   D 36
   E 46

4) 3 mol of a gas is present in a container of volume V dm^3 at a pressure of 1000 Pa and a temperature of 27°C. Which of the following expressions correctly gives the value of V?

   A $V = \dfrac{3\times8.31\times27}{1000}$

   B $V = \dfrac{3\times8.31\times300\times10^6}{1000000}$

   C $V = \dfrac{3\times0.0821\times300}{1000000}$

   D $V = \dfrac{3\times62.4\times300\times1000}{1000000}$

   E $V = \dfrac{3\times8.31\times300\times1000}{1000}$

5) What mass of **potassium** is present in 37.3 g of potassium chloride (RFM = 74.6)?
   A 746 g
   B 19.6 g
   C 37.3 g
   D 39.1 g
   E 9.8 g

6) Copper displaces silver from a solution of silver nitrate according to the equation
   $Cu(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + CuNO_3(aq)$
   How many moles of silver are displaced by 0.1 mol of copper?
   A 2 mol
   B 0.5 mol
   C 0.1 mol
   D 0.2 mol
   E 0.05 mol

7) A gas occupies a volume of 1.0 dm^3 at a pressure of 1.0 atm. The temperature is held constant. If the number of moles of the gas is tripled and the pressure is adjusted to 2 atm, the volume becomes
   A 0.17 dm^3
   B 0.67 dm^3
   C 1.0 dm^3
   D 1.5 dm^3
   E 6.0 dm^3

8) Which one of the following is **NOT** considered to be a basic principle of the kinetic theory of gases?
   A The volume of the molecules themselves is negligible in comparison with the total volume occupied by the gas.
   B The forces between molecules are negligible except during collisions.
   C The molecules of a gas are in a state of continuous random motion.
   D The temperature of a gas is a measure of the average kinetic energy of the molecules.
   E At constant temperature all the molecules in a gas have the same speed.

9) 0.5 mol of potassium carbonate (K_2CO_3) contains
   A 3 mol of oxygen atoms.
   B 0.5 mol of oxygen atoms.
   C 6×10^{23} mol of oxygen atoms.
   D 1.5 mol of oxygen atoms.
   E 6×10^{23} mol of oxygen.

10) Which one of the following has the greatest mass?
A 1.2×10^{24} atoms of oxygen.
B 3 mol of sulphur atoms.
C 150 g of hydrogen.
D 22.4 dm^3 of liquid water.
E 6×10^{23} molecules of water.

11) The rate of effusion of oxygen divided by the rate of effusion of sulfur dioxide is closest to:
A 0.25
B 0.5
C $\sqrt{2}$
D 2
E 4

12) A 12 cm^3 sample (measured at S.T.P.) of a gaseous hydrocarbon of formula C_2H_6 is burned in just sufficient oxygen to turn it completely into carbon dioxide and water. After cooling to the original temperature, the volume of gas is:
A 12 cm^3
B 24 cm^3
C 36 cm^3
D 60 cm^3
E 72 cm^3

13) A certain hydrocarbon contains 80% by mass of carbon. The empirical formula
A is C_2H_4
B is CH_3
C is CH_2
D is CH
E cannot be found without more information.

14) The percentage by mass of silver in silver sulfate (Ag_2SO_4)
A is 108%
B is 34.6%
C is 216%
D is 69.2%
E depends on the mass of silver sulfate.

15) A blue solution gives a pale blue precipitate when treated with dilute ammonia solution. The blue precipitate redissolves on the addition of excess ammonia and forms a deep blue solution. This test identifies
A the anion present as sulfate.
B the cation present as copper(II)
C the cation present as copper(I)
D the anion present as nitrate.
E the cation present as iron(II).

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SECTION B: STRUCTURED QUESTION

Answer **ALL** questions in this section in the spaces provided on the question paper.

1) Write one **balanced net ionic** equation in each of the following cases: (10 marks)

a) Dilute sodium hydroxide solution added to a solution of lead(II) nitrate to form a white precipitate.

$Pb^{2+}(aq) + 2OH^-(aq) \rightarrow Pb(OH)_2(s)$

b) Dilute ammonia solution added to a solution of iron(II) chloride solution to form a green precipitate.

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ or

$2H_2O(l) + Fe^{2+}(aq) + 2NH_3(aq) \rightarrow Fe(OH)_2(s) + 2NH_4^+(aq)$

c) Dilute ammonia solution added to a precipitate of zinc hydroxide to form a colourless solution.

$Zn(OH)_2(s) + 4NH_3(aq) \rightarrow [Zn(NH_3)_4]^{2+}(aq) + 2OH^-(aq)$

d) Barium chloride solution added to a solution of zinc sulfate to form a white precipitate.

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

e) Silver nitrate solution added to a solution of sodium bromide to form a cream precipitate.

$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$

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2) 2.00 g of a compound which contains only carbon, hydrogen ***and oxygen*** are burnt in air. 3.82 g of carbon dioxide and 2.35 g of water are obtained. The RMM of this compound is 46. (Use RAM of C = 12.0, H = 1.01 and O = 16.0.)

a) Find the number of moles of CO_2 and of H_2O formed. (4 marks)

$n_{CO_2} = \frac{\text{mass}}{\text{molar mass}} = \frac{3.82\text{ g}}{(12.0+2\times16.0)\text{ g mol}^{-1}}$ STO1 $= 0.086818\ldots$ mol $= \underline{0.0868\text{ mol}}$ to 3 s.f.

$n_{H_2O} = \frac{2.35}{(2\times1.01+16)} = 0.13041\ldots$ mol. $= \underline{0.130\text{ mol}}$ to 3 s.f.

b) Find the number of moles of C atoms and of H atoms the compound contained. (2 marks)

∴ mol of C atoms $= \underline{0.0868\text{ mol}}$

H atoms $= \underline{0.261}$ mol.

c) Find the mass of C and of H the compound contained. (2 marks)

∴ Mass of C $= 0.0868\text{ mol} \times \frac{12.0\text{ g}}{\text{mol}} = \underline{1.04\text{ g}}$ STO3

Mass of H $= 0.261\text{ mol} \times \frac{1.01\text{ g}}{\text{mol}} = \underline{0.263\text{ g}}$

d) Find the mass of O the compound contained. (1 mark)

Mass of compound − mass of C − mass of H

$= 2.00\text{ g} - 1.04\text{ g} - 0.263\text{ g} = 0.69475\ldots\text{ g}$

$= \underline{0.695\text{ g}}$ to 3 s.f.

e) Find the empirical formula of the compound. (3 marks)

Moles of O $= \frac{0.695\text{ g}}{16.0\text{ g mol}^{-1}} = 0.043422\text{ mol}$. STO3

∴ Mole Ratio C : H : O $= 0.0868 : 0.261 : 0.043422$

$= 1.999\ldots : 6.0066\ldots : 1$ (dividing by smallest)

$= 2 : 6 : 1$ (nearest whole numbers)

∴ Empirical formula is $\underline{C_2H_6O}$

f) Find the molecular formula of the compound. (1 mark)

RFM of $C_2H_6O = 2\times12.0 + 6\times1.01 + 16.0$

$= 46.01$

Since RFM = RMM, molecular formula is

$\underline{C_2H_6O}$

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3) a) Calculate the pressure of 0.100 mol of methane gas at 105°C if it occupies a container of capacity 5.24 L. (4 marks)

$PV = nRT$

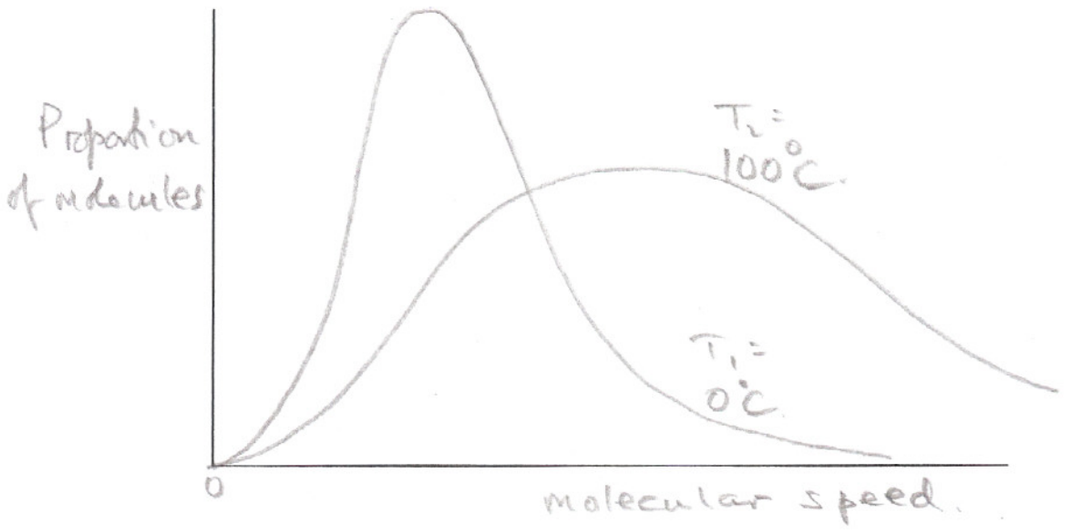
$\therefore P = \frac{nRT}{V} = \frac{0.1 \times 0.0821 \times (105+273)}{5.24} = 0.592248...$

$= 0.592$ atm to 3 s.f.

b) When the calculation is repeated for water vapour, assuming ideal behaviour, the same answer is obtained, but in this case the actual pressure only approaches the calculated pressure at an appreciably larger volume. Explain this with reference to the kinetic theory of gases. (2 marks)

Water vapour does not behave ideally under these conditions. Forces between molecules are appreciable, and the molecules themselves do not occupy negligible volume. As volume increases these approximations (0 volume, 0 forces) become more nearly true.

c) Using the axes given, show the distribution of molecular speeds in a sample of gas at two temperatures (e.g. 0°C and 100°C): T_1 and T_2 (where $T_2 >> T_1$). Label the axes. (4 marks)



d) Account for one major difference between the two distributions in light of the kinetic-molecular theory of gases.

(2 marks)

The most common speed is greater at the higher temp. or there is a greater proportion of molecules with high speed at the higher temp. or there is a lower proportion of molecules with low speed at the higher temp. etc etc.

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