SECTION A – Multiple choice questions (20 marks)

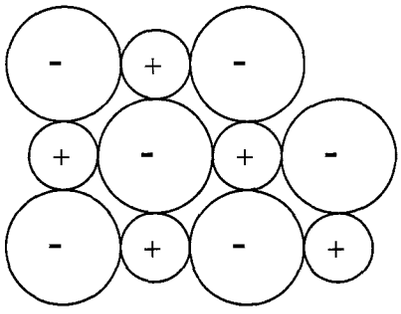
1	**C**	5	**D**	9	**B**	13	**C**	17	**A**
2	**A**	6	**C**	10	**B**	14	**B**	18	**D**
3	**A**	7	**B**	11	**D**	15	**A**	19	**B**
4	**D**	8	**D**	12	**C**	16	**C**	20	**A**

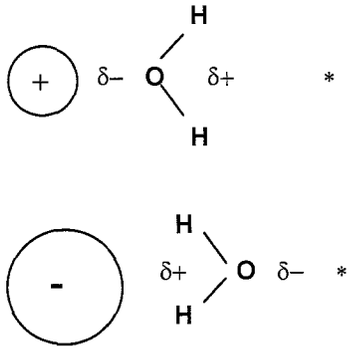
SECTION B – Short answer questions (54 marks)

*** = 1 mark**

Question 1 (4 marks)

a.





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b. Hydrogen bonding * occurs between the oxygen atom in an ethanol molecule and the hydrogen atoms in a water molecule* (or between the hydrogen atom attached to the oxygen in an ethanol molecule with the oxygen atom in a water molecule).

Question 2 (9 marks)

a. $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ *

b. Sulfurous acid does not extensively ionise in aqueous solution. *

c. Sulfurous acid in solution can donate two protons *

$H_2SO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HSO_3^-(aq)$ *

$HSO_3^-(aq) + H_2O(l) \rightarrow H_3O^+(aq) + SO_3^{2-}(aq)$ *

d. (i) H_2SO_3 * **(ii)** SO_3^{2-} *

e. Give credit for any principle of green chemistry* and its relevant use in this situation.*

For example, raw materials should be renewable where possible, e.g. by replacing diesel fuel with biodiesel.

Or, converting waste materials into more useful products, e.g. by converting the sulfur dioxide produced in the smelting process into the more useful sulfuric acid.

Question 3 (7 marks)

a. (i) A_r(Ag) = 107.9 n(Ag) = 1000/107.9 = 9.268 mol *

(ii) $n(HNO_3)$ = 2 X 9.268 = 18.54 mol *

(iii) $V(HNO_3)$ = 18.54/14.0 = 1.32 L *

b. (i) A_r(Al) = 27.0 n(Al) = 6.00/27.0 = 0.222 mol *

(ii) $A_r(Br_2)$ = 159.8 $n(Br_2)$ = 12.0/159.8 = 0.0751 mol *

(iii) From the mole ratio, 0.222 mol of Al requires 0.333 mol of Br_2 for complete reaction

As only 0.0751 mol of Br_2 is available, aluminium is the excess reactant. *

Mol of Al that reacts = (0.0751 X 2/3) = 0.0500 mol

Mole of Al in excess = 0.222 – 0.0500 = 0.172 mol *

Question 4 (7 marks)

a. 80 g $NaNO_3$ / 80 g water = 100 g $NaNO_3$ / 100 g water.

Saturated solution at 40 °C. *

b. At 60 °C a saturated solution contains 120 g $NaNO_3$ / 100 g water *

Mass of $NaNO_3$ in 250 mL saturated solution = 120 X 250/100

= 300 g *

c. The solution is unsaturated. *

d. The solution is supersaturated. *

e. At 40 °C, 100 g $NaNO_3$ dissolves in 100 g water. *

The mass of crystals = (125 – 100) = 25g *

Question 5 (8 marks)

a. The air initially has to be purified to remove traces of dust, water vapour, carbon dioxide. *

The air is compressed under pressure until it liquefies. *

The liquid is warmed, and nitrogen with a lower boiling point is collected from the top of the fractionating column, leaving oxygen (and traces of argon) lower in the column. *

b. (i) $n(KNO_3)$ = 1.01 / 101.1 = 0.0100 mol *

$n(O_2)$ = 2 X 0.0100 = 0.0200 mol *

(ii) Volume (O_2) = 0.0200 X 24.5 = 0.490 L *

(iii) Use $P_1V_1/T_1 = P_2V_2 / T_2$ to solve for volume of oxygen under the given conditions

Then 101.3 X 0.490 / 298 = 100 X $V(O_2)$ / 288 * for correct substitution of values

$V(O_2)$ = 0.479 L *

Alternatively, using PV = nRT, Temp = 288 K

$V(O_2)$ = (0.0200 X 8.31 X 288) / 100 * for correct substitution of values

= 0.479 L *

Question 6 (8 marks)

a. (i) Equation 1 is the oxidation step. *

(ii) $2Fe(s) + O_2(g) + 2H_2O(l) \rightarrow 2Fe^{2+}(aq) + 4\ OH^-(aq)$ * correct formulas for reactants and products

* balanced

(iii) The salt solution contains ions to facilitate the flow of charges through the galvanic cell that results in the corrosion of iron. *

b. (i) Ag^+ is the strongest oxidant * as it was the only ion to react with (oxidise) three metals. *

(ii) In order of decreasing reducing strength, Zn > Co > Pb > Ag *

(iii) $2Ag^+(aq) + Co(s) \rightarrow 2Ag(s) + Co^{2+}(aq)$ *

Question 7 (5 marks)

a. To use PV = nRT P = 100kPa, V = 0.150L, T = 293K * correct conversions

$n(Ar) = \frac{PV}{RT} = \frac{100 \times 0.150}{8.31 \times 293}$

$= 6.16 \times 10^{-3}$ mol *

b. $P_1V_1 = P_2V_2$ $V_2 = P_1V_1 / P_2$

$V(Ar) = 100 \times 150 / 200$

$= 75$ mL *

c. When the volume is compressed, the particles have less room to move around in. If the temperature is unchanged, their average kinetic energies are unchanged *, and they will collide with the walls of the container more frequently *, which is measured as an increase in pressure.

Question 8 (6 marks)

(a)

(i) Nitrogen fixation is the conversion of elemental nitrogen into compounds that can be used by plants. *

(ii) Through lightning e.g. in thunderstorms, **or** through action by nitrogen-fixing bacteria in the soil *

(iii) Through combustion engines e.g in cars, **or** through the Haber process for producing ammonia *

(b)

(i) The products are N_2 = 20 L and H_2O = 60 L, total volume of 80 L *

(ii) Oxygen is now in excess.

20 L of NH_3 reacts with 15 L of O_2, leaving 15 L of O_2 unreacted.

The products are N_2 = 10 L and H_2O = 30 L, volume of products = 40 L *

Total volume of gases after reaction = 40 L (products) + 15 L (excess O_2) = 55 L *