**PART 1 (60 marks = 30% of paper)**

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided. Each question in this part is worth 2 marks.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1 | **B** | 11 | **D** | 21 | **D** |
| 2 | **B** | 12 | **B** | 22 | **A** |
| 3 | **A** | 13 | **C** | 23 | **C** |
| 4 | **D** | 14 | **B** | 24 | **A** |
| 5 | **A** | 15 | **C** | 25 | **C** |
| 6 | **A** | 16 | **D** | 26 | **C** |
| 7 | **C** | 17 | **B** | 27 | **D** |
| 8 | **C** | 18 | **C** | 28 | **C** |
| 9 | **C** | 19 | **D** | 29 | **D** |
| 10 | **D** | 20 | **C** | 30 | **C** |

**END OF PART 1**

**PART 2 (70 marks = 35% of paper)**

Answer ALL questions in Part 2 in the spaces provided below.

1. Write equations for any reactions that occur in the following procedures. If no reaction occurs, write ‘no reaction’.

In each case describe in full what you would observe, including any: colours;

odours; precipitates (give the colour); or gases evolved (give the colour or

describe as colourless). If a reaction occurs but the change is not visible, then

you should state this.

(a) Solid potassium carbonate is added to excess nitric acid.

Equation **K2CO3(s) + 2 H+(aq) 2 K+(aq) + H2O(l) + CO2(g)**

Observation **A white solid dissolves forming a colourless solution and**

**an odourless, colourless gas evolves *(must have both)***

(b) Dilute sulfuric acid is added to barium chloride solution.

Equation **Ba2+(aq) + SO42–(aq) BaSO4(s)**

Observation **Two colourless solutions are mixed forming a white precipitate**

(c) Nickel(II) oxide is added to an ethanoic acid solution.

Equation **NiO(s) + 2 CH3COOH(aq) Ni2+(aq) + 2 CH3COO­–(aq) + H2O(l)**

Observation **A grey (green acceptable) solid dissolves forming a green solution**

(d) A piece of sodium is added to ethanal.

Equation **No reaction**

Observation **No visible reaction**

(12 marks)

2. For each species listed in the table below draw the structural formula,

representing all valence shell electron pairs either as : or –.

|  |  |  |  |
| --- | --- | --- | --- |
| *Species* | *Structural formula* | *Shape* | *Polarity* |
| N2O  (NNO) | **:::::Desktop:Picture 2.png**  **or**  **:::::Desktop:Picture 3.png** | **Linear** | **Polar** |
| ONCl | **Picture 10** | **Bent** | **Polar** |
| AsCl3 | **:::::Desktop:Picture 1.png** | **Trigonal pyramidal** | **Polar** |

(12 marks)

3. Identify the most important forces of attraction in determining the melting point

of the following solids:

(a) NH4Cl **Ionic bonds**

(b) SO3 **Dispersion forces**

(c) CH3NH2 **Hydrogen bonds**

(d) SiC **Covalent bonds**

(4 marks)

4. Sketch graphs that depict the following trends:

(a) Electronegativity of the period 3 elements

|  |  |
| --- | --- |
| Electronegativitiy |  |
|  | Na Mg Al Si P S Cl |

(1 mark)

(b) First ionisation energies of elements carbon to magnesium.

|  |  |
| --- | --- |
| First  ionisation  energy |  |
|  | C N O F Ne Na Mg |

**'peak' at Ne, 'trough' at Na**  (2 marks)

5. Account for the trend in solubility in water for the following alcohols:

|  |  |
| --- | --- |
| *Alcohol* | *Solubility*  *(g/100g water at 20ºC)* |
| methanol | miscible in all proportions |
| ethanol | miscible in all proportions |
| 1-propanol | miscible in all proportions |
| 1-butanol | 8.14 |
| 1-pentanol | 2.64 |
| 1-hexanol | 0.59 |
| 1-heptanol | 0.09 |

**Methanol propanol**

**Miscible in all proportions because the hydrogen bonds formed between these alcohols and water are similar in strength to that between water**

**molecules and between the alcohol molecules.**

**Butanol heptanol**

**Decreasing solubility with increasing chain length because the dispersion**

**forces that form between the hydrocarbon 'tail' and water molecules are**

**much weaker than the hydrogen bonds between water molecules (and dispersion forces between larger alcohols).**

(4 marks)

6. (a) Use the numbers 1 to 6 to rank the following molecules from

highest boiling point (1) to lowest boiling point (6)

|  |  |  |
| --- | --- | --- |
| *Name* | *Molar mass*  *(g mol–1)* | *Rank* |
| butane,  CH3CH2CH2CH3 | 58.1 | **5** |
| ethanoic acid, CH3COOH | 60.1 | **1** |
| methylpropane,  CH3CH(CH3)CH3 | 58.1 | **6** |
| propanal,  CH3CH2CHO | 58.1 | **4** |
| 1-propanol, CH3CH2CH2OH | 60.1 | **2** |
| 2-propanol,  CH3CH(OH)CH3 | 60.1 | **3** |

**1/2 each** (3 marks)

(b) Account for the difference in boiling point between propanal and

1-propanol.

**Both have a similar molecular mass and shape, therefore similar**

**dispersion forces**

**1-propanol - hydrogen bonding; propanal - dipole-dipole forces**

**Since hydrogen bonding is stronger more energy is required to**

**overcome intermolecular forces, therefore 1-propanol has the higher**

**boiling point.**

(3 marks)

7. Consider the following information:

Compound **A**, a colourless liquid with formula C3H8O, reacts with concentrated

phosphoric acid to give compound **B**, with formula C3H6, which rapidly discolours

a solution of bromine water.

When a piece of sodium is added to compound **A** an odourless, colourless gas

evolves.

When compound **A** is treated with concentrated ethanoic acid compound **C**,

a sweet smelling liquid with formula C5H10O2, is formed.

When compound **A** is completely oxidised by reaction with acidified potassium

dichromate compound **D**, with formula C3H6O, is formed.

When a piece of sodium is added to compound **D**, there is no visible reaction.

(a) Draw structural formula and give IUPAC names for the following:

|  |  |  |
| --- | --- | --- |
| *Compound* | *Structural formula* | *IUPAC name* |
| A |  | **2-propanol** |
| B |  | **propene** |
| C |  | **2-propyl ethanoate** |
| D |  | **propanone** |

**each** (8 marks)

(b) (i) Write an equation for the reaction of compound **A** with sodium.

**2 (CH3)2CHOH + 2 Na 2 (CH3)2CHO–Na+ + H2**

(ii) Name the organic product of the reaction.

**sodium 2-propoxide**

(3 marks)

(c) (i) Write an equation for the reaction of compound **B** with a solution of

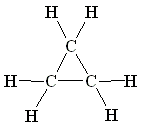
bromine water.

**CH3CHCH2 + Br2 CH3CHBrCH2Br**

(ii) Name the organic product of the reaction.

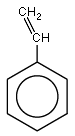
**1,2-dibromopropane**

(iii) Name and sketch an isomer of compound **B**, which would not rapidly discolour a solution of bromine water.

**cyclopropane** Picture 1 **or** 

(5 marks)

8. The structure of styrene is:



(a) Name type of polymer that styrene will form.

**Addition polymer**

(1 mark)

(b) Sketch a section of polystyrene with at least three monomer units.

|  |
| --- |
| ::Picture 4.png |

(2 marks)

9. Ammonium carbamate (NH4OCONH2) decomposes forming ammonia and

carbon dioxide, according to the following equilibrium:

NH4OCONH2(s) ⇄ 2 NH3(g) + CO2(g) ΔH = – 450 kJ mol–1

(a) Write an expression for the equilibrium constant, K.

**K = [NH3]2.[CO2]**

(1 mark)

(b) Three vessels contain an equilibrium mixture of this system, each of which

is subjected to one of the changes described below. In each case,

describe the effect of the change on:

- the rate of the forward reaction (increase, decrease, no change)

- the mass of CO2 (increase, decrease, no change)

- the value of the equilibrium constant, K (increase, decrease, no change)

once equilibrium has been re-established.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Vessel* | *Change* | *Forward reaction rate* | *Mass of CO2* | *Value of K* |
| 1 | Increase in temperature | **↑** | **↓** | **↓** |
| 2 | Addition of neon gas at constant volume | **–** | **–** | **–** |
| 3 | Increase in volume at constant temperature | **–** | **↑** | **–** |

**each** (9 marks)

**END OF PART 2**

**PART 3 (50 marks = 25% of paper)**

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b), and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information that may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you do not, you will lose marks.

1. **(a) Ca2+(aq) + C2O42–(aq) CaC2O4(s)**

**(b) n(CaC2O4) = m/M = 0.937 / 128.1 = 0.007315 mol**

**n(CaCO3) = n(Ca2+) = n(CaC2O4) = 0.007315 mol**

**m(CaCO3) = n.M = 0.007315 x 100.09 = 0.7321 g**

**%(CaCO3) = 0.7321 / 1.42 = 51.6%**

**(c) n(HCl) = n(H+) = 2 x n(CaCO3) = 0.01463 mol**

**V(HCl) = n/c = 0.01463 / 0.200 = 0.0731 L or 73.1 mL**

2. **(a) m(Fe2O3) = 25 x 106 g x 87/100 = 21.75 x 106 g**

**n(Fe2O3) = m/M = 21.75 x 106 / 159.7 = 1.362 x 105 mol**

**n(CO) = PV/RT = (110 x 1.53 x 107) / (8.315 x 750)**

**= 2.699 x 105 mol**

**n(CO) required = 3 x n( Fe2O3) = 4.086 x 105 mol > actual**

**Therefore, CO is limiting.**

**(b) n(Fe) = 2/3 n(CO) = 1.800 x 105 mol**

**m(Fe) = n.M = 1.800 x 105 x 55.85 = 1.00 x 107 g**

**or 10.0 tonnes**

3. **(a) H+(aq) + OH–(aq) H2O(l)**

**(b) n(OH–) = n(NaOH) = c.v = 0.150 x 0.0920 = 0.01380 mol**

**n(H+) = n(OH–) = 0.01380 mol**

**[H+] = n/V = 0.01380 / 0.0250 = 0.552 mol L–1**

**(c) Ba2+(aq) + SO42–(aq) BaSO4(s)**

**(d) n(BaSO4) = m/M = 1.56 / 233.36 = 0.006685 mol**

**n(H2SO4) = n(SO42–) = n(BaSO4) = 0.006685 mol**

**Therefore, [H2SO4] = n/V = 0.006685 / 0.0500 = 0.134 mol L–1**

**(e) [H+]H2SO4 = 2 x [H2SO4] = 0.267 mol L–1**

**[HNO3] = [H+]HNO3 = 0.552 - 0.267 = 0.285 mol L–1**

4. **(a) m(MnO2) = 2.00 x 106 x 73/100 = 1.46 x 106 g**

**n(MnO2) = m/M = 1.46 x 106 / 86.94 = 16 790 mol**

**Assuming 100% efficiency:**

**n(Mn) = n(MnO2) = 16 790 mol**

**m(Mn) = n.M = 16970 x 54.94 = 9.226 x 105 g**

**Taking into account efficiency:**

**m(Mn) = 9.226 x 105 x 83/100 x 94/100 = 7.20 x 105 g**

**or 0.720 tonnes**

**(b) Assuming 100% efficiency:**

**n(O2) = 1/3 n(MnO2) = 5597 mol**

**V(O2) = nRT/P = (5657 x 8.315 x 773.1) / 105 = 3.426 x 105 L**

**Taking into account efficiency:**

**V(O2) = 3.426 x 105 x 83/100 = 2.84 x 105 L**

**(c) n(Mn) = m/M = 7.20 x 105 / 54.94 = 13100 mol**

**Assuming 100% efficiency:**

**n(Al) = 5/9 n(Mn) = 11650 mol**

**m(Al) = n.M = 11650 x 26.98 = 3.14 x 105 g**

**Taking into account efficiency:**

**m(Al) = 3.14 x 105 x 100/94 = 3.34 x 105 g**

**or 0.334 tonnes**

5. **(a) n(C) = n(CO2) = m/M = 7.48 / 44.01 = 0.1693 mol**

**m(C) = n.M = 0.1693 x 12.01 = 2.033 g**

**%(C) = 2.033 / 5.00 x 100 = 40.66%**

**n(H) = 2 x n(H2O) = 2 x m/M = 2 x 2.77 / 18.016 = 0.3075 mol**

**m(H) = n.M = 0.3075 x 1.008 = 0.3100 g**

**%(H) = 0.3100 / 5.00 x 100 = 6.20%**

**n(N) = n(NO2) = m/M = 0.938 / 46.01 = 0.02039 mol**

**m(N) = n.M = 0.02039 x 14.01 = 0.2856 g**

**%(N) = 0.2856 / 3.00 x 100 = 9.52%**

**%(O) = 100 - %(C) - %(H) - %(N) = 43.62%**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **C** | **:** | **H** | **:** | **N** | **:** | **O** |
| **40.66** | **:** | **6.20** | **:** | **9.52** | **:** | **43.62** |
| **12.01** | **1.008** | **14.01** | **16** |
| **3.39** | **:** | **6.15** | **:** | **0.680** | **:** | **2.73** |
| **0.680** | | | | | | |
| **4.98** | **:** | **9.04** | **:** | **1** | **:** | **4.01** |

**Therefore, EF = C5H9NO4**

**(b) In 20.0 mL:**

**n(OH–) = c.v = 0.5 x 0.0248 = 0.0124 mol**

**n(H+) = n(OH–) = 0.0124 mol**

**n(glutamic acid) = 1/2 n(H+) = 0.00620 mol**

**m(glutamic acid) = 4.56 x 20/100 = 0.912 g**

**M(glutamic acid) = m/n = 0.912 / 0.00620 = 147.1 g mol–1**

**EFM = 147.132, therefore MF = EF = C5H9NO4**

**End of Part 3**

**PART 4 (20 marks = 10% of paper)**

Points to be mentioned:

**Preparation : Equilibrium and Rates principles**

|  |  |
| --- | --- |
| **Conditions used** | **reasons** |
| Temperature of 300oC : a compromised temperature | Rate : this high temperature will increase rate of reaction :  More collisions – KE inc; vel inc; collisions inc  More molecules now have the required Act Eng.  Yield : Since reaction is exothermic, an increase in temp. would favour the reverse reaction [the endo reaction] so yield suffers.  Therefore 300oC : compromise |
| Pressure of 60-70 atm | Rate will increase with this pressure since there will be more collisions.  Yield will also increase since acc. to LCP the reaction will shift to side with less gas molecules [product].  The pressure used is not that high since there is a possibility of loss of ethane due to polymerization and also reduce cost of building very high Press Equipment |
| Catalyst : H3PO4 | This increases the rate of reaction by lowering the act. Eng so now more molecules have the required Ea. However cat. Has no effect on yield. |
| < 1 vol steam | Although ratio of reactants are 1:1 less steam is used since it interferes with the catalyst. |

**Physical and Chemical Properties**

|  |  |
| --- | --- |
| Soluble in H2O | Both are CMLiquids, both are polar and both have H-Bond as their intermolecular forces. So solute-solvent interactions are favourable |
| Boiling point | Unusually high since ethanol is CMLiquid, polar molecule and has H-Bond as its intermolecular forces. |
| + Na | 2CH3CH2OH + 2 Na = H2 + 2 CH3CH2O-Na+; reacts spontaneously with reactive metals to give H2(g) |
| + O2 | Very good fuel; reacts with O2 to give CO2 and H2O  CH3CH2OH + 3 O2 = 2 CO2 + 3 H2O + heat |
| + carboxylic acids : | Forms esters with acids  CH3CH2OH + CH3COOH = H2O + CH3COOCH2CH3 |
| oxidation | With MnO4-/H+ and Cr2O72-/H+ it forms aldehyde CH3CHO and then with excess CH3COOH |