Instructions

- This paper consists of two sections A and B
- Section A is compulsory
- Attempt only six questions in section B
- Answers must be written in the spaces provided only.
SECTION A

Answer all questions from this section

1. Oxygen diffused through a porous partition in 1.87 minutes. Under similar conditions the same volume of an alkene T diffused in 2.15 minutes
   (a) Determine the formula of T (2 ½ marks)

   (b) Write equation and outline the mechanism for the reaction between T and benzene.

   Indicate the condition(s) for the reaction (3 marks)

2. (a) Define the term heat of reaction (1 mark)

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(c) Calculate the standard enthalpy of hydrogenation of ethane from the data

(i) \[ \text{C}_2\text{H}_6(g) + 3 \frac{1}{2} \text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l) \quad \Delta H = -1550\text{kJmol}^{-1} \]

(ii) \[ \text{C}_2\text{H}_4(g) + 3 \text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 2\text{H}_2\text{O}(l) \quad \Delta H = -1390\text{kJmol}^{-1} \]

(iii) \[ \text{H}_2(g) + \frac{1}{2} \text{O}_2(g) \rightarrow \text{H}_2\text{O}(l) \quad \Delta H = -285.8\text{kJmol}^{-1} \] (4marks)

3. (a) Aluminium and phosphorus both form compounds in which the oxidation state of the element is +3

(a) Briefly explain in terms of electron structure why aluminium conducts electricity but the common allotropes of phosphorus do not.

(b) Write equation for the reaction of each of these elements with sodium hydroxide (3mark)
4. Name one reagent that can be used to distinguish between each of the following pairs of compounds and state what would be observed in each case if the reagent is reacted with the compounds;

(a) \( \text{CH}_3\text{CH}_2\text{NH}_2 \) and \( (\text{CH}_3\text{CH}_2)_2\text{NH} \) (3 marks)

Reagent

Observation:

(b) \[
\begin{align*}
\text{COCH}_2\text{CH}_3 \\
\text{and} \\
\text{CH}_2\text{COCH}_3
\end{align*}
\]
5. (a) Explain the order of increasing basicity for the following compounds. (2 marks)

\[ \text{C}_6\text{H}_5\text{NH}_2 \quad \text{NH}_3 \quad \text{CH}_3\text{NH}_2 \]

(b) When one mole of methylamine is dissolved in water, the hydrogen ion concentration is found to be \(2.5 \times 10^{-10}\ \text{moldm}^{-3}\).

(i) Write an equation for the reaction between water and methylamine (1 mark)

(ii) Calculate the base dissociation constant, \(K_b\), for methylamine. (2½ marks)
6. The convention of a cell is given below.

\[ \text{Pt}/\text{Fe}^{2+}(\text{aq}),\text{Fe}^{3+}(\text{aq})//\text{MnO}_4^-(\text{aq}),\text{Mn}^{2+}(\text{aq}),\text{H}^+(\text{aq})/\text{Pt} \]

(a) Write equation for the half-cell reaction at:

(i) Anode

(ii) Cathode

(b) Write the overall equation for the cell reaction.

(c) The electrode potentials for the system Fe^{2+}(aq)/Fe^{3+}(aq) and Mn^{2+}(aq)/MnO_4^-(aq) are +0.76V and -1.51V respectively. Deduce whether the reaction in (b) is feasible or not and give a reason for your answer.
7. (a) Define the term boiling point elevation constant of a substance. (1mark)

(b) The boiling point of benzene under certain pressure condition is 80.0°C. Calculate the boiling point elevation constant of benzene, if a solution containing 5g of 2,4,6-trinitrophenol, \((\text{HOC}_6\text{H}_2(\text{NO}_2)_3)\) in 100g of benzene, boils at 80.568°C. (4marks)

8. 2.00g of phosphorus pentachloride allowed to reach equilibrium at 200°C in a vessel of 1dm³ capacity. If the equilibrium constant of the reaction \(\text{PCl}_5 (g) \rightleftharpoons \text{PCl}_3(g) + \text{Cl}_2(g)\) is 0.008moldm⁻³ at this temperature and in the conditions stated; calculate the percentage dissociation of phosphorus pentachloride at equilibrium. (4marks)
9. The first ionization energies of some group II metals of the periodic table and the melting points of their chlorides are given below.

<table>
<thead>
<tr>
<th></th>
<th>Mg</th>
<th>Ca</th>
<th>Sr</th>
<th>Ba</th>
</tr>
</thead>
<tbody>
<tr>
<td>First ionization energy /kJmol(^{-1})</td>
<td>738</td>
<td>590</td>
<td>549</td>
<td>505</td>
</tr>
<tr>
<td>Melting point of chlorides (°C)</td>
<td>708</td>
<td>772</td>
<td>873</td>
<td>967</td>
</tr>
</tbody>
</table>

Explain

(i) Why ionization decreases with increase in atomic number. (2marks)

(ii) Why the melting points of the chlorides of these metals increase with increase in atomic number of the metal. (2marks)
SECTION B (54 MARKS)

(Attempt any six questions from this section)

10. (a) (i) Define the term “molar conductivity at infinite dilution, \( \Lambda_0 \).”  

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11. (a) (i) Explain the term solubility product. (1 mark)

(ii) Write an expression for the solubility product of silver chloride in water (1 mark)

(b) Ionic conductivity of silver ions and chloride ions at infinite dilution are $6.2 \times 10^{-2}$ and $7.6 \times 10^{-2}$ Sm$^2$mol$^{-1}$ respectively at 298K. The electrolytic conductivity of silver chloride at 298K is $1.22 \times 10^{-2}$ Sm$^2$mol$^{-1}$.

(i) Calculate the solubility in mold$^{-3}$ of silver chloride at 298K (3 ½ marks)

(ii) Calculate the solubility product, Ksp, of silver chloride at 298K (1 ½ marks)
(c) State the effect of the following actions on the solubility of silver chloride. Explain your answers.

(i) Addition of aqueous ammonia (1mark)

(ii) Addition of potassium chromate (VI) solution. (1mark)

12. Write equations to show how the following compounds can be synthesized.

(a) \[
\text{COCH}_3 \quad \text{from} \quad \text{Cl} \]

(b) \((\text{CH}_3)_3\text{COH}\) from \((\text{CH}_3)_2\text{CHOH}\) (2½ marks)

(c) \(\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2\) from ethyne (3marks)
13. (a) Explain each of the following observations:

(i) Chromium (III) sulphate dissolves in water to form a solution whose pH is less than seven. (2 ½ marks)

(ii) Lead does not form lead (IV) bromide. (2 marks)

(b) To a dilute solution of chromium (III) sulphate was added dilute sodium hydroxide drop wise until in excess followed by 3 drops of hydrogen peroxide and mixture warmed.

State what was observed and use equations to explain the observations. (4 ½ marks)

14. Complete the following equations and in each case write a mechanism for the reaction.

(a) [Equation and mechanism] (3 marks)
15. Vegetable oils have great economic and social importance.

(a)(i) Explain what is meant by the term **vegetable oils**  

(b) \[\text{(CH}_3\text{)}_3\text{CBr} \xrightarrow{\text{NaOH}} \text{C}_2\text{H}_5\text{OH, Heat} \] (3marks)

(c) \[\text{CH}_3\text{CH} = \text{CH}_2 + \text{CoH}_2\text{SO}_4 \xrightarrow{\text{H}_2\text{O}} \text{warm} \] (3marks)
(ii) Name two main sources of vegetable oils. (1mark)

(iii) Describe briefly how vegetable oil can be obtained on a large scale from one of the sources you have named in (a)(i) above. (technical details are not required) (2marks)

(b) (i) State the name given to the reaction leading to the formation of soap from oil. (1mark)

(ii) Write a general equation for the formation of soap from oil. (1mark)

(iii) Outline how soap is manufactured, (technical details not required). (3marks)

16. State what would be observed and write the equation for the reaction that would take place when:
(a) Hydrogen sulphide gas is passed through an acidified solution of potassium dichromate (VI).
(b) 2,3 drops of ammoniacal copper (I) chloride is added to phenylethyne.  (2marks)

(b) 2,3 drops of ammoniacal copper (I) chloride is added to phenylethyne.  (2marks)

(c) Neutral iron (III) chloride solution is added to 1 cm$^3$ of propanoic acid  (2marks)

(c) Neutral iron (III) chloride solution is added to 1 cm$^3$ of propanoic acid  (2marks)
(d) A spatula end ful of sodium hydrogen carbonate is added to iron (III) chloride solution (2½ marks)
Observation

Equation:

17. (a) Fluorine is the first member of the halogen group of elements in the periodic table and it shows anomalous behavior among the halogens.

(i) State three major differences between fluorine and other halogens. (2½ marks)

(ii) Give three causes for the anomalous behaviour of fluorine. (3 marks)

(c) The acid dissociation constants $K_a$ for the hydrides of elements of group (VII) elements are given in the table below:
State and explain the trend in variation of acid strength of the hydrides (4 marks)

<table>
<thead>
<tr>
<th>Hydride</th>
<th>HF</th>
<th>HCl</th>
<th>HBr</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_a (\text{mol dm}^{-3})$</td>
<td>$5.6 \times 10^{-11}$</td>
<td>$1 \times 10^{-9}$</td>
<td>$1 \times 10^{-7}$</td>
<td>$1 \times 10^{-4}$</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td>----</td>
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</tr>
<tr>
<td>1.0</td>
<td>H</td>
<td></td>
<td>1.0</td>
<td>H</td>
</tr>
<tr>
<td>6.9</td>
<td>Li</td>
<td></td>
<td>10.8</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>Be</td>
<td></td>
<td>12.0</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>27.0</td>
<td>Al</td>
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<tr>
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<td></td>
<td></td>
<td>32.1</td>
<td>Si</td>
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<td>40.0</td>
<td>Ge</td>
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<td></td>
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<td>79.9</td>
<td>Ti</td>
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<td>79.9</td>
<td>Co</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>83.8</td>
<td>Mo</td>
</tr>
</tbody>
</table>

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