SECTION A
(Answer all questions)

1. Complete the following equation of radioactive decay

(a) \( ^{233}_{91} Pa \rightarrow \beta + \ldots \ldots \ldots \rightarrow ^{4}_{2} He + \ldots \ldots \ldots \) (2 marks)

(b) \( ^{223}_{88} Ra \rightarrow \ldots + ^{219}_{86} Rn \rightarrow \ldots \ldots \ldots + ^{215}_{84} Po \) (2 marks)

(c) \( ^{207}_{81} Ti \rightarrow \ldots \ldots + ^{207}_{82} Pb \) (1 mark)

2. Draw the shapes and name the structure of each of the following species (2 marks each)
<table>
<thead>
<tr>
<th>Species</th>
<th>Shape</th>
<th>Name of the Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₃O⁺</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Write an equation for dissolution of each of the following salt in water. State whether the resulting solution would be neutral, basic or acidic
   (a) chromium (III) chloride (2marks)
   
   (b) Magnesium chloride (1mark)
   
   (c) ammonium methanoate (2marks)

4. (a) Complete the following equations
   i. CH₃CH₂COCH₃ + H₂NNH-C₆H₅ → .................................. (1mark)
   
   ii. C₆H₅COOH + CH₃OH → H⁺ → .................................. (1½ mark)
   
   iii. nCH₂=CH-C = CH₂ Cl → .................................. (1mark)
iv. \((\text{CH}_3)_3\text{C-Br} + \text{OH}^{\text{aq}} \rightarrow \) .................................................. (1mark)

(b) State the name of the mechanism of the reaction in (a)(iv) (2marks)

5. 20.0 cm\(^3\) of 0.02M sodium hydroxide was added to 30 cm\(^3\) of 0.025M sulphuric acid. Calculate

a. Molar concentration of the hydrogen ions in the initial sulphuric acid (1 ½ mark)

b. Concentration of hydrogen ions in the resultant solution (3marks)

c. The pH of the resultant solution (1mark)

6. (a) Write the electron configuration of an atom of aluminium (1mark)

(b) State the possible oxidation number of aluminium (½ mark)

(c) Write an ionic equation for the reaction between aluminium and sodium hydroxide (1½ marks)
7. Name one regent that can be used to distinguish between each of the following pairs of compound and state what would be observed in each case if the reagents reacted with the compounds.

(a) \( \text{C}_6\text{H}_5\text{COCH}_2\text{CH}_3 \) and \( \text{C}_6\text{H}_5\text{COCH}_3 \)

Reagent

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) \( \text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \) and \( \text{(CH}_3\text{)}_3\text{COH} \)

Reagent

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. The convention of a cell is given below

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

(a) Write equation for the half cell reaction at

(i) anode (1 marks)

(ii) cathode (1 marks)

(b) Write the overall equation for the cell reaction (1½ marks)

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(c) The electrode potential of system \( \text{Fe}^{3+}(aq)/\text{Fe}^{2+}(aq) \) and \( \text{MnO}_4^-(aq)/\text{Mn}^{2+}(aq) \) are 0.76 and 1.51 volts respectively. Deduce whether the reaction in (b) is feasible or not and give a reaction for your answer. (1 mark)

9. Write an
(i) equation for the reaction between hydrogen and nitrogen. (1 mark)

(ii) expression for equilibrium constant \( (K_p) \) of the reaction in (a)(i) above. And state its units (2 marks)

(b) When hydrogen was reacted with nitrogen at 895K, the total pressure for the system at equilibrium was 30 atmospheres, and the partial pressure of nitrogen and hydrogen were 2 and 6 atmospheres respectively.
(i) Determine the partial pressure of ammonia in equilibrium mixture (1 mark)

(ii) Calculate equilibrium constant (1½ marks)

SECTION B
Answer six questions from this section

10. (a) State the oxidation state of chromium in

(i) Potassium chromate (1 mark)

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(i) Potassium dichromate  

(b) Acidified potassium dichromate was reacted with potassium iodide

(i) State what was observed  

(ii) Write half equations and overall equations for the reactions.  

(c) Potassium chromate solution was added to aqueous Lead (II) nitrate

(i) State what was observed  

(ii) Write the ionic equation for the reaction  

11. Complete the following reactions and suggest mechanisms for the reaction
(a) \( 2(\text{CH}_3)_2\text{CO} \rightarrow \text{dil NOH} \rightarrow \) Room temp.  

Mechanism
12 Explain the following:

(a) Aqueous solutions of chromium (II) and chromium (III) are colored while that of copper (I) is not.

(b) Manganese, iron, cobalt and nickel form ions in the +2 oxidation states. State which decrease in size from manganese to nickel.

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(c) The oxy-acids, HClO₂ and HClO₄ have the following respective structures.

\[
\begin{align*}
\text{H-O-Cl=O} & \quad \text{and} \\
\text{H-O-Cl=O} & \quad \text{H-O-Cl=O}
\end{align*}
\]

Explain why HClO₄ is stronger acid than HClO₂

(Assume that oxygen is more electronegative than chlorine) (2 marks)

(d) Iron III sulphate solution changes litmus paper red (2 marks)

13 (a) State Kohlrausch’s law of independent Conductivity of ions (1 mark)

(b) Some ionic conductivity at infinite dilution at 250°C are shown below

<table>
<thead>
<tr>
<th>Ion</th>
<th>Ionic conductivity (Ω⁻¹cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH⁻</td>
<td>198.6</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>76.4</td>
</tr>
<tr>
<td>NH₄⁺</td>
<td>73.6</td>
</tr>
<tr>
<td>Na⁺</td>
<td>50.1</td>
</tr>
</tbody>
</table>

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Calculate the molar conductivity of ammonium hydroxide at infinite dilution (2 marks)

……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………

(c) The ionic radii and ionic conductivities at infinite dilution of some ions are shown in the table below:

<table>
<thead>
<tr>
<th>Ion</th>
<th>Ionic radius/nm</th>
<th>Ionic conductivity/Ω⁻¹cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li⁺</td>
<td>0.060</td>
<td>38.7</td>
</tr>
<tr>
<td>Na⁺</td>
<td>0.095</td>
<td>50.1</td>
</tr>
<tr>
<td>K⁺</td>
<td>0.133</td>
<td>73.5</td>
</tr>
</tbody>
</table>

Explain the values in the table (3 marks)

……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………

(d) The diagram below shows curves a and b obtained when aqueous sodium hydroxide was gradually added separately to equimolar solution of hydrochloric and ethanoic acid separately

Explain the shape of the curves
(i) curve a (1½ marks)

……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
14. Compound Y, C₃H₆O reacts with 2, 4-dinitrophenylhydrazine to give a yellow solid.
   (a) Write the structural formulae and IUPAC names of all isomers of Y. (2 marks)
   ………………………………………………………………………………………………………………
   ………………………………………………………………………………………………………………

   (b) When Y is heated with Fehling’s solution, a red precipitate is formed. Identify Y (1 mark)
   ………………………………………………………………………………………………………………
   ………………………………………………………………………………………………………………

   (c) Write a mechanism for the reaction that would take place between Y and hydroxylamine, NH₂OH. (3 marks)
   ………………………………………………………………………………………………………………
   ………………………………………………………………………………………………………………

   (d) Write equations to show how Y can be converted to an alkene (3 marks)
   ………………………………………………………………………………………………………………
   ………………………………………………………………………………………………………………

15. (a) An aqueous solution containing 7.2g of a non-cyclic substance Q in 250g of water freezes at -0.744°C; the freezing point constant, K, for water is 1.86mol⁻¹kg⁻¹. (3 marks)
   ………………………………………………………………………………………………………………
   ………………………………………………………………………………………………………………

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(b) If Q contains carbon, 66.7%, hydrogen, 11.1% and oxygen 22.2%  

(i) Calculate the simplest formula of Q  

(ii) Determine the molecular formula of Q  

(iii) Write the structures of all possible isomers of Q  

(d) Q forms a yellow precipitate with phenyl hydrazine and iodine solution in presence of sodium hydroxide. Identify Q.  

16. The solubility product, Ksp, of zinc hydroxide is $4.5 \times 10^{-17}$ at 25°C  

(i) Write an expression for solubility product of zinc hydroxide  

(b) Determine the concentration in moles per litre of zinc hydroxide ions in a saturated solution of zinc hydroxide at 25°C  

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(c) State how solubility of zinc hydroxide would change if its saturated solution is treated separately with

(i) aqueous zinc sulphate (1 mark)

(ii) ammonia (1 mark)

(d) Briefly explain your answer in (c). (3 marks)

17. Figure 2 is a phase diagram for a certain substance
(a) Label the following on the diagram
   (i) the axes
   (ii) the phases present
   (iii) the critical temperature
   (iv) the triple point
(b) Define the term
   (i) Critical point
   (ii) triple point
(c) Explain what would happen when the substance at point X changes to point B

Periodic Table

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>1.0</td>
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<tr>
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<td>226</td>
<td>Ra</td>
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</tbody>
</table>

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