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525/1

S6 CHEMISTRY

Exam 5

PAPER 1

DURATION: 2 HOUR 45 MINUTES

For Marking guide contact and consultations: Dr. Bbosa Science 0776 802709.

Instructions to candidates:
- Attempt all questions in section A and any six from section B
- All questions are to be answered in the spaces provided
- A periodic table with relevant atomic masses is supplied at the end of the paper.

<table>
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<th>FOREXAMINER’S USE ONLY</th>
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</table>
1. (a) Define the term enthalpy of formation. (1 mark)

(b) Calculate the enthalpy of formation sodium chloride from the following data. (3 marks)

<table>
<thead>
<tr>
<th>Reaction</th>
<th>ΔH° (kJmol⁻¹)</th>
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<tbody>
<tr>
<td>Na(s) → Na(g)</td>
<td>+109</td>
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<tr>
<td>Cl₂(g) → 2Cl(g)</td>
<td>+242</td>
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<tr>
<td>Na⁺(g) + Cl⁻(g) → NaCl(s)</td>
<td>-771</td>
</tr>
<tr>
<td>Cl(g) + e⁻ → Cl⁻(g)</td>
<td>-364</td>
</tr>
</tbody>
</table>
(a) \[ \text{CH}_3 \text{CH}_2 | \text{MnO}_4^- | \text{OH} (ag) \]  
\[ \text{heat} \]

(b) \[ \text{BrCH}_2\text{CHCH}_2\text{CH}_2\text{Br} | \text{EtOH} | \text{EtOH} \]  
\[ \text{Heat} \]

(c) \[ \text{CH}_3 \text{CHC} \equiv \text{CH} + \text{H}_2 \]  
\[ \text{Lindlar’s catalyst} \]

3. 0.02M methylamine solution is 4% ionized at 25°C.
   (a) Write;
      (i) an equation for the ionization of methylamine in water. (1 mark)
      \[ \text{ } \]
      \[ \text{ } \]
      (ii) an expression for the base ionization constant \( K_b \) for methylamine. (1 mark)
      \[ \text{ } \]
      \[ \text{ } \]

   (b) Calculate the
      (i) pH of the methylamine solution (\( K_w = 1.0 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6} \))
      \[ \text{ } \]
      \[ \text{ } \]
4. (a) Write the formula of the hydrides of sodium and sulphur, in each case state the type of bonds present in the compounds.  

<table>
<thead>
<tr>
<th>Elements</th>
<th>Formula of hydride</th>
<th>Type of bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Write equations to show how the hydrides react with water.  

5. (a) Define the term Osmotic pressure.  

(ii) base ionization constant; \(K_b\) for methylamine.  

(1 \(\frac{1}{2}\) marks)
(b) A polysaccharide has the formula \((\text{C}_{12}\text{H}_{12}\text{O}_{11})_n\). A solution containing 5.00 g dm\(^{-3}\) of the sugar has an osmotic pressure of \(7.12 \times 10^2\) Nm\(^{-2}\) at 20°C. Find the value of \(n\). (3 \frac{1}{2} \text{ marks})

(c) State any two assumptions made in (b) above. (1 mark)

6. A powdered element T was investigated as shown in the table below

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) A mixture of T and lead (IV) oxide was heated</td>
<td>A colourless gas with a choking smell and turned acidified potassium dichromate from orange to green was evolved.</td>
</tr>
<tr>
<td>(b) Concentrated nitric acid is added to heated T, the products were diluted and barium nitrate solution added.</td>
<td>T dissolved in nitric acid with effervescence of a brown gas. On addition of barium nitrate solution a white precipitate was formed</td>
</tr>
</tbody>
</table>

(i) Identify T (1 mark)
(ii) Write equations for the reactions in experiments (a) and (b) (4 marks)

7. (a) 20cm$^3$ of hydrocarbon Q with general formula C$_n$H$_{2n-2}$ were mixed with 100cm$^3$ of oxygen. The mixture was ignited and the residual gaseous product at room temperature bubbled through concentrated potassium hydroxide solution. The final volume was found to be 20cm$^3$.
(i) Calculate the value of n in Q. (2 marks)

(ii) Deduce the molecular formula of Q. (½ mark)

(b) Q has two isomers X and Y. X decolourises bromine water but it does not react with ammoniacal silver nitrate solution. Y forms a white precipitate with ammoniacal silver nitrate solution.
(i) Identify isomers X and Y (1 mark)

(ii) Write an equation for the reaction between (1 mark)
8. Name the reagent(s) that can be used to distinguish between each of the following compounds. State what would be observed in each case.

(a) KI(aq) and KCl(aq) (1 ½ marks)

Reagent(s)

Observations

(b) \( \text{COONa} \) and \( \text{OH}^{-} \) (1 ½ marks)

Reagent(s)

Observations

(c) \( \text{PbCO}_{3}(s) \) and \( \text{BaCO}_{3}(s) \) (1 ½ marks)

Reagent(s)
9. The electrode potentials of $\text{S}_2\text{O}_8^{2-}(aq) \mid \text{SO}_4^{2-}(aq)$ and $\text{I}_2(aq) \mid \text{I}^-(aq)$ are +2.01V and +0.54V respectively.

(a) Write an equation for the reaction that occurs at the;
   (i) anode  
   (1 mark)

(b) Write the;
   (i) Cathode  
   (1 mark)

(c) (i) calculate the e.m.f of the cell generated from the cell reaction in b(ii) above.  
   (1 mark)

(ii) State whether the above cell reaction is feasible or not. Give a reason for your answer  
   (1 mark)
SECTION B: (54 MARKS)

Answer only six questions from this section

10. Write equations to show how the following conversions can be effecte4d. Indicate all reagents and conditions necessary for each reaction.

(a) 1 – methylcyclobutene to 2 – methyl cyclobutanol. (3 marks)

(b) From benzene and bromomethane (4 marks)

(c) Butane – 2, – diol to 2,3 –butane dionedioxime. (2 marks)
11. (a) Be(OH)$_2$, Mg(OH)$_2$, Ca(OH)$_2$ and Ba(OH)$_2$ are the hydroxides of group II elements. Briefly describe how the hydroxides react with:

(i) sodium hydroxide solution

(ii) hydrochloric acid solution

(b) The solubilities of the hydroxides of group II elements of the periodic table at 25°C are given below

<table>
<thead>
<tr>
<th>Hydroxide</th>
<th>Be(OH)$_2$</th>
<th>Mg(OH)$_2$</th>
<th>Ca(OH)$_2$</th>
<th>Sr(OH)$_2$</th>
<th>Ba(OH)$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solubility g/100g of water</td>
<td>Insoluble</td>
<td>0.002</td>
<td>0.150</td>
<td>0.900</td>
<td>4.000</td>
</tr>
</tbody>
</table>

(i) State and explain the trend in solubility of the hydroxides.
(ii) Different masses of solid \( \text{Ca(OH)}_2 \) and \( \text{Ba(OH)}_2 \) containing the same number of moles were separately shaken with the same volume of water at 25\(^\circ\)C. Identify the solution with higher pH value. Give a reason for your answer

(1 ½ marks)

12. (a) The partition coefficient of ammonia between water and trichloromethane at 25\(^\circ\)C is 25.0,

(i) Define the term partition coefficient. (1 ½ marks)

(ii) State two conditions under which the partition coefficient \( (K_D = 25.0) \) is valid other than constant temperature. (1 mark)

(b) 25cm\(^3\) of 0.0056M nickel (II) sulphate solution were added to an unequal volume of ammonia solution at 25\(^\circ\)C. The mixture was shaken with 50cm\(^3\) of
trichloromethane and allowed to stand until equilibrium was established. The trichloromethane layer required 32cm$^3$ of 0.0025M hydrochloric acid for complete neutralization. 7.060cm$^3$ of the aqueous layer required 20cm$^3$ of 0.02M hydrochloric acid. Nickel (II) ions react with ammonia according to the equation; 

\[
\text{Ni}^{2+}(\text{aq}) + n\text{NH}_3(\text{aq}) \rightarrow [\text{Ni(NH}_3)_n]^{2+}(\text{aq})
\]

Calculate

(i) Molar concentration of the free ammonia in the aqueous layer. (2 1/2 marks)

(ii) Molar concentration of ammonia that reacted with nickel (II) ions (2 marks)

(iii) Use your answer b (II) above to determine the value of n in [Ni(NH$_3$)$_n$]$^{2+}$
13. (a) Describe a simple chemical test to distinguish between CH\textsubscript{3}COCH\textsubscript{3} and CH\textsubscript{3}CH\textsubscript{2}CHO (2 marks)

(b) Compound Z can be synthesized by the reaction between X and Y as shown below

\[ \text{CH}_3\text{CH}_2\text{CHO} \quad \text{Step I} \rightarrow X \quad \text{Step III} \rightarrow \text{O} \quad \text{CH}_3\text{CH}_2\text{C} \quad \text{OCH(CH}_3)_2 \quad \text{CH}_3\text{COCH}_3 \quad \text{Step II} \rightarrow Y \]

(i) Identify compounds X and Y

(ii) Name the type of reaction that occurs in steps I and I (1 mark)

(c) Identify the reagents and state the conditions necessary for the reaction in

(i) step I (1 mark)

(ii) step III (2 marks)

(d) Write the mechanism for the reaction that occurs in step III

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14. Explain each of the following observations.
   (a) An aqueous solution sodium sulphite when mixed with ammonium chloride produce a colourless gas that forms dense white fumes with concentrated hydrochloric acid on warming. (3 marks)
   (b) The acid dissociation constant (Ka) of chloric (I) acid is lower than the Ka for chloric (VII) acid at 25°C, (2 marks)
   (d) When refluxed with aqueous potassium hydroxide followed by acidified silver nitrate solution. Chloroethane forms a white precipitate which chlorobenzene gives no observable change. (4 mark)
15. HF, HCl, HBr and HI are hydrides of group VII elements
(a) Explain the variation in boiling points of the hydrides. (3 marks)
(b) Aqueous solutions of the hydrides of the same concentration at constant
temperature have different pH values.
(i) Identify the hydride whose solution in water has the lowest pH (1 mark)
(ii) Give a reason for your answer in b(i) above. (2 marks)
(c) Write an equation for the reaction between
(i) The hydride of fluorine and excess silicon (IV) oxide

(ii) Potassium manganate (VII) solution and the hydride of chlorine.

(iii) Concentrated sulphuric acid and the hydride of bromine.

16. Lead (II) iodide is a sparingly soluble salt.
(a) Write an equation for the solubility of lead (II) iodide in water

(b) The concentration of a saturated solution of lead (I) iodide at 40°C is 0.122 g per 100 cm³ of solution
State whether a mixture of 50 cm³ of 0.01 M lead (II) nitrate and 50 cm³ of 0.001 M potassium iodide forms a yellow precipitate of lead (II) iodide or not. (show your working clearly)
(c) The saturated solution of lead (II) iodide of concentration 0.122g per 100cm$^3$ of solution was heated to 60$^\circ$C in a closed system
(i) State whether the solution remains saturated at 60$^\circ$C ( $\frac{1}{2}$ mark)
(ii) Give a reason for your answer. (1 $\frac{1}{2}$ marks)

17. A mixture of methanol and water at 50$^\circ$C is an ideal solution. The partial vapour pressure of methanol in the vapour above the solution varies according to Raoult’s law as shown in the table below.

<table>
<thead>
<tr>
<th>Partial vapour pressure of methanol (mmHg)</th>
<th>40.0</th>
<th>100.0</th>
<th>200.0</th>
<th>260.0</th>
<th>320.0</th>
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<tbody>
<tr>
<td>Mole fraction of methanol in solution</td>
<td>0.10</td>
<td>0.25</td>
<td>0.50</td>
<td>0.65</td>
<td>0.80</td>
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</table>

(a) (i) Define the term ideal solution. (1 mark)
(ii) State Raoul’s law (1 mark)
……………………………………………………………………………………………………
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(b) On the same axes, plot a graph of;
   (i) Vapour pressure of methanol
   (ii) Total vapour pressure above the solution against mole fraction of methanol.
       (The composition of methanol in the vapour is 50% when its mole fraction in solution is 0.19)

(c) Use your graphs in (b) above to determine the
   (i) Saturated vapour pressure of methanol at 50°C. (1 mark)
       ………………………………………………………………………………………………………
   (ii) Saturated vapour pressure of water at 50°C
       ………………………………………………………………………………………………………

(d) Compare the volatility of methanol and water at 50°C. Give a reason for your answer. (1 mark)
……………………………………………………………………………………………………
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# THE PERIODIC TABLE

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<tr>
<td><strong>1</strong>&lt;br&gt;<strong>H</strong>&lt;br&gt;1.0</td>
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<td><strong>2</strong>&lt;br&gt;<strong>He</strong>&lt;br&gt;4.0</td>
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<td><strong>3</strong>&lt;br&gt;<strong>Li</strong>&lt;br&gt;6.9</td>
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<td><strong>4</strong>&lt;br&gt;<strong>Be</strong>&lt;br&gt;9.0</td>
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<td><strong>5</strong>&lt;br&gt;<strong>B</strong>&lt;br&gt;10.8</td>
<td><strong>6</strong>&lt;br&gt;<strong>C</strong>&lt;br&gt;12.0</td>
<td><strong>7</strong>&lt;br&gt;<strong>N</strong>&lt;br&gt;14.0</td>
<td><strong>8</strong>&lt;br&gt;<strong>O</strong>&lt;br&gt;16.0</td>
<td><strong>9</strong>&lt;br&gt;<strong>F</strong>&lt;br&gt;19.0</td>
<td><strong>10</strong>&lt;br&gt;<strong>Ne</strong>&lt;br&gt;20.2</td>
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<td><strong>11</strong>&lt;br&gt;<strong>Na</strong>&lt;br&gt;23.0</td>
<td><strong>12</strong>&lt;br&gt;<strong>Mg</strong>&lt;br&gt;24.3</td>
<td><strong>13</strong>&lt;br&gt;<strong>Al</strong>&lt;br&gt;27.0</td>
<td><strong>14</strong>&lt;br&gt;<strong>Si</strong>&lt;br&gt;28.1</td>
<td><strong>15</strong>&lt;br&gt;<strong>P</strong>&lt;br&gt;31.0</td>
<td><strong>16</strong>&lt;br&gt;<strong>S</strong>&lt;br&gt;32.1</td>
<td><strong>17</strong>&lt;br&gt;<strong>Cl</strong>&lt;br&gt;35.4</td>
<td><strong>18</strong>&lt;br&gt;<strong>Ar</strong>&lt;br&gt;40.0</td>
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<td><strong>19</strong>&lt;br&gt;<strong>K</strong>&lt;br&gt;39.1</td>
<td><strong>20</strong>&lt;br&gt;<strong>Ca</strong>&lt;br&gt;40.1</td>
<td><strong>21</strong>&lt;br&gt;<strong>Sc</strong>&lt;br&gt;45.0</td>
<td><strong>22</strong>&lt;br&gt;<strong>Ti</strong>&lt;br&gt;47.9</td>
<td><strong>23</strong>&lt;br&gt;<strong>V</strong>&lt;br&gt;50.9</td>
<td><strong>24</strong>&lt;br&gt;<strong>Cr</strong>&lt;br&gt;52.0</td>
<td><strong>25</strong>&lt;br&gt;<strong>Mn</strong>&lt;br&gt;54.9</td>
<td><strong>26</strong>&lt;br&gt;<strong>Fe</strong>&lt;br&gt;55.8</td>
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<td><strong>37</strong>&lt;br&gt;<strong>Rb</strong>&lt;br&gt;85.5</td>
<td><strong>38</strong>&lt;br&gt;<strong>Sr</strong>&lt;br&gt;87.6</td>
<td><strong>39</strong>&lt;br&gt;<strong>Y</strong>&lt;br&gt;88.9</td>
<td><strong>40</strong>&lt;br&gt;<strong>Zr</strong>&lt;br&gt;91.2</td>
<td><strong>41</strong>&lt;br&gt;<strong>Nb</strong>&lt;br&gt;92.9</td>
<td><strong>42</strong>&lt;br&gt;<strong>Mo</strong>&lt;br&gt;95.9</td>
<td><strong>43</strong>&lt;br&gt;<strong>Te</strong>&lt;br&gt;98.9</td>
<td><strong>44</strong>&lt;br&gt;<strong>Ru</strong>&lt;br&gt;101</td>
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<td><strong>55</strong>&lt;br&gt;<strong>Cs</strong>&lt;br&gt;133</td>
<td><strong>56</strong>&lt;br&gt;<strong>Ba</strong>&lt;br&gt;137</td>
<td><strong>57</strong>&lt;br&gt;<strong>La</strong>&lt;br&gt;138</td>
<td><strong>58</strong>&lt;br&gt;<strong>Ce</strong>&lt;br&gt;140</td>
<td><strong>59</strong>&lt;br&gt;<strong>Pr</strong>&lt;br&gt;141</td>
<td><strong>60</strong>&lt;br&gt;<strong>Nd</strong>&lt;br&gt;144</td>
<td><strong>61</strong>&lt;br&gt;<strong>Pm</strong>&lt;br&gt;145</td>
<td><strong>62</strong>&lt;br&gt;<strong>Sm</strong>&lt;br&gt;152</td>
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<tr>
<td><strong>87</strong>&lt;br&gt;<strong>Fr</strong>&lt;br&gt;(223)</td>
<td><strong>88</strong>&lt;br&gt;<strong>Ra</strong>&lt;br&gt;(226)</td>
<td><strong>89</strong>&lt;br&gt;<strong>Ac</strong>&lt;br&gt;(227)</td>
<td><strong>90</strong>&lt;br&gt;<strong>Th</strong>&lt;br&gt;232</td>
<td><strong>91</strong>&lt;br&gt;<strong>Pa</strong>&lt;br&gt;231</td>
<td><strong>92</strong>&lt;br&gt;<strong>U</strong>&lt;br&gt;238</td>
<td><strong>93</strong>&lt;br&gt;<strong>Np</strong>&lt;br&gt;237</td>
<td><strong>94</strong>&lt;br&gt;<strong>Pu</strong>&lt;br&gt;(244)</td>
</tr>
</tbody>
</table>

1. **H** indicates Atomic number.

2. **H** indicates relative Atomic number.

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END.