**A-LEVEL CHEMISTRY**

**PAPER 1**

**PRACTICE PAPER 9**

Answer all questions

Max 105 marks

2 hours

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|  | Name …………………………………………………………….. |  |
|  | Mark ……../105 ……....% Grade ……… |  |

**1.** This table contains some values of lattice dissociation enthalpies.

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| --- | --- | --- | --- | --- |
|  | **Compound** | MgCl2 | CaCl2 | MgO |
|  | **Lattice dissociation enthalpy / kJ mol−1** | 2493 | 2237 | 3889 |

(a)     Write an equation, including state symbols, for the reaction that has an enthalpy change equal to the lattice dissociation enthalpy of magnesium chloride.

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**(1)**

(b)     Explain why the lattice dissociation enthalpy of magnesium chloride is greater than that of calcium chloride.

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**(2)**

(c)     Explain why the lattice dissociation enthalpy of magnesium oxide is greater than that of magnesium chloride.

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**(2)**

(d)     When magnesium chloride dissolves in water, the enthalpy of solution is −155 kJ mol−1.  
The enthalpy of hydration of chloride ions is −364 kJ mol−1.

Calculate the enthalpy of hydration of magnesium ions.

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**(3)**

(e)     Energy is released when a magnesium ion is hydrated because magnesium ions attract water molecules.

Explain why magnesium ions attract water molecules.  
You may use a labelled diagram to illustrate your answer.

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**(2)**

(f)      Suggest why a value for the enthalpy of solution of magnesium oxide is **not** found in any data books.

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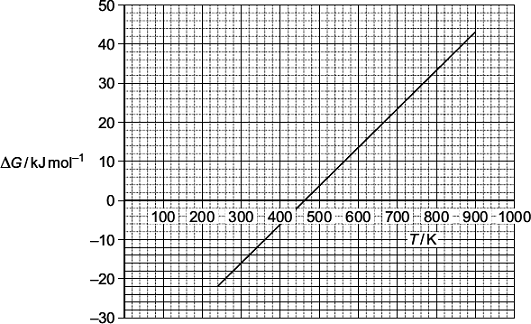
**(1)**

**(Total 11 marks)**

**2.** The following equation shows the formation of ammonia.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| N2(g) | + | H2(g) |  | NH3(g) |

The graph shows how the free-energy change for this reaction varies with temperature above 240 K.



(a)     Write an equation to show the relationship between ∆*G*, ∆*H* and ∆*S*.

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**(1)**

(b)     Use the graph to calculate a value for the slope (gradient) of the line. Give the units of this slope and the symbol for the thermodynamic quantity that this slope represents.

Value of the slope ..........................................................................................

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Units ...............................................................................................................

Symbol ...........................................................................................................

**(3)**

(c)     Explain the significance, for this reaction, of temperatures below the temperature value where the line crosses the temperature axis.

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**(2)**

(d)     The line is not drawn below a temperature of 240 K because its slope (gradient) changes at this point.

Suggest what happens to the ammonia at 240 K that causes the slope of the line to change.

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**(1)**

**(Total 7 marks)**

**3.** This question is about Brønsted-Lowry acids of different strengths.

(a)     State the meaning of the term *Brønsted–Lowry acid*.

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**(1)**

(b)    (i)      Write an expression for the acid dissociation constant *K*a for ethanoic acid.

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**(1)**

(ii)     The value of *K*a for ethanoic acid is 1.75 × 10−5 mol dm−3 at 25 °C.

Calculate the concentration of ethanoic acid in a solution of the acid that has a pH of 2.69

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**(4)**

(c)     The value of *K*a for chloroethanoic acid (ClCH2COOH) is 1.38 × 10−3 mol dm−3 at 25 °C.

(i)      Write an equation for the dissociation of chloroethanoic acid in aqueous solution.

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**(1)**

(ii)     Suggest why chloroethanoic acid is a stronger acid than ethanoic acid.

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**(2)**

(d)     **P** and **Q** are acids. **X** and **Y** are bases. The table shows the strength of each acid and base.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Acids** | | **Bases** | |
|  | strong | weak | strong | weak |
|  | **P** | **Q** | **X** | **Y** |

The two acids were titrated separately with the two bases using methyl orange as indicator.  
The titrations were then repeated using phenolphthalein as indicator.  
The pH range for methyl orange is 3.1 − 4.4  
The pH range for phenolphthalein is 8.3 − 10.0

For each of the following titrations, select the letter, **A, B, C,** or **D**, for the correct statement about the indicator(s) that would give a precise end-point.  
Write your answer in the box provided.

**A** Both indicators give a precise end-point.

**B** **Only** methyl orange gives a precise end-point.

**C** **Only** phenolphthalein gives a precise end-point.

**D** Neither indicator gives a precise end-point.

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| --- | --- | --- | --- |
|  | (i) | Acid **P** with base **X** |  |

**(1)**

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| --- | --- | --- | --- |
|  | (ii) | Acid **Q** with base **X** |  |

**(1)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | (iii) | Acid **Q** with base **Y** |  |

**(1)**

(e)     Using a burette, 26.40 cm3 of 0.550 mol dm−3 sulfuric acid were added to a conical flask containing 19.60 cm3 of 0.720 mol dm−3 aqueous sodium hydroxide.  
Assume that the sulfuric acid is fully dissociated.

Calculate the pH of the solution formed.

Give your answer to 2 decimal places.

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**(6)**

**(Total 18 marks)**

**4.** When 1.00 mol dm–3 solutions of salicylic acid and sodium hydroxide are mixed a buffer solution can be formed. Salicylic acid is a monoprotic acid that can be represented by the formula HA.

(a)     Select a mixture from the table below that would produce a buffer solution. Give a reason for your choice.

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| --- | --- | --- | --- |
|  | **Mixture** | **Volume of 1.00 mol dm–3  salicylic acid solution / cm3** | **Volume of 1.00 mol dm–3  sodium hydroxide solution / cm3** |
|  | **X** | 25 | 75 |
|  | **Y** | 50 | 50 |
|  | **Z** | 75 | 25 |

Mixture ...........................................................................................................

Reason ..........................................................................................................

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**(2)**

(b)     Another mixture, formed by adding 50 cm3 of 1.00 mol dm–3 salicylic acid solution to 25 cm3 of 1.00 mol dm–3 sodium hydroxide solution, can be used to determine the p*K*a of salicylic acid. State **one** measurement that must be made for this mixture and explain how this measurement can be used to determine the pKa of salicylic acid.

Measurement .................................................................................................

Explanation ....................................................................................................

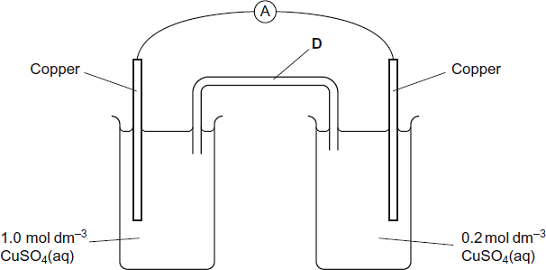
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**(3)**

**(Total 5 marks)**

**5.** An electrochemical cell is shown in the diagram. In this cell, the amount of copper in the electrodes is much greater than the amount of copper ions in the copper sulfate solutions.



(a)     Explain how the salt bridge **D** provides an electrical connection between the two electrodes.

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**(1)**

(b)     Suggest why potassium chloride would **not** be a suitable salt for the salt bridge in this cell.

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**(1)**

(c)     In the external circuit of this cell, the electrons flow through the ammeter from right to left.

Suggest why the electrons move in this direction.

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**(2)**

(d)     Explain why the current in the external circuit of this cell falls to zero after the cell has operated for some time.

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**(1)**

(e)     The simplified electrode reactions in a rechargeable lithium cell are

Electrode **A**    Li+ + MnO2 + e−   LiMnO2     *E =* −0.15 V

Electrode **B**    Li+ + e−  Li

Electrode **B**    is the negative electrode.

(i)      The e.m.f. of this cell is 2.90 V.

Use this information to calculate a value for the electrode potential of electrode **B**.

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**(1)**

(ii)     Write an equation for the overall reaction that occurs when this lithium cell is being **recharged**.

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**(2)**

(iii)    Suggest why the recharging of a lithium cell may lead to release of carbon dioxide into the atmosphere.

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**(1)**

**(Total 9 marks)**

**6.** In a test, aqueous iron(III) ions are reduced to aqueous iron(II) ions by iodide ions.   
This reaction could be used to provide electrical energy in a cell.

(a)     The standard electrode potential for the reduction of iron(III) ions into iron(II) ions can be measured by connecting a suitable electrode to a standard hydrogen electrode.   
Draw a clearly labelled diagram to show the components and reagents, including their concentrations, in this Fe(III)/Fe(II) electrode.   
Do **not** draw the salt bridge or the standard hydrogen electrode.

**(3)**

(b)     A salt bridge is used to complete the cell. This could be prepared using potassium nitrate solution and filter paper.

State the purpose of the salt bridge. State **one** essential requirement of the soluble ionic compound used to make the salt bridge.

Purpose of salt bridge ....................................................................................

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Requirement ..................................................................................................

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**(2)**

**(Total 5 marks)**

**7.**      (a)     The ion  can act as a bidentate ligand.

(i)      Explain the meaning of the term *bidentate ligand*.

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(ii)     Sketch the structure of the octahedral complex ion formed by Fe3+ ions which contains  as the only ligand. Include the overall charge on the complex ion.

**(5)**

(b)     Explain the meaning of the term *chelate effect*.

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**(2)**

(c)     The chloride ion can act as a monodentate ligand.

(i)      Deduce the formula of the linear complex formed when an excess of concentrated hydrochloric acid is added to silver chloride.

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(ii)     Explain why metal(II) ions do not usually form octahedral complexes when chloride ions are the only ligands.

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**(2)**

(d)     The concentration of  ions can be determined by titration in acidic solution using a standard solution of potassium manganate(VII). At room temperature, the reaction proceeds very slowly at first but becomes faster after some of the manganate(VII) ions have reacted.

(i)      Suggest why this reaction is very slow at first.

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(ii)     This is an example of an autocatalytic reaction. State the meaning of the term *autocatalytic* and identify the catalyst.

*Meaning of the term autocatalytic* ........................................................

*Catalyst* ................................................................................................

(iii)     Suggest how this catalyst might be involved in the reaction.

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**(5)**

**(Total 14 marks)**

**8.**      (a)     In the Haber Process for the manufacture of ammonia, the following equilibrium is established in the presence of a heterogeneous catalyst.

N2(g) + 3H2(g)  2NH3(g)

Identify the heterogeneous catalyst used in this process and state what is meant by the term *heterogeneous*.

A heterogeneous catalyst can become poisoned by impurities in the reactants.   
Give one substance which poisons the heterogeneous catalyst used in the Haber Process and explain how this substance poisons the catalyst.

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(b)     State what is observed when an excess of aqueous ammonia reacts with an aqueous iron(II) salt. Write an equation for this reaction.

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**(4)**

**(Total 9 marks)**

**9.** When using potassium manganate(VII) in redox titrations with iron(II) ions it is essential that the reaction mixture is acidified. Normally, dilute sulfuric acid is used.

(a)     State why an excess of hydrogen ions is added to the reaction mixture.

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**(1)**

(b)     State why the acid used must **not** be ethanoic acid.

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**(1)**

(c)     Explain why an indicator is **not** needed in this redox titration.

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**(1)**

**(Total 3 marks)**

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| **10.** |  |
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|  | **(Total 4 marks)** |

**11.** A biocide is a chemical that kills bacteria. A biocide is added to prevent the growth of bacteria in the water used in vases of flowers. Household bleach contains aqueous chlorine and can be used as the biocide. The concentration of chlorine in vase water decreases with time. It was decided to investigate the rate of this decrease.

The following experimental method was used to determine the concentration of chlorine in vase water at different times.

•        A sample of vase water was taken.

•        An excess of potassium iodide solution was added to the sample.

•        The chlorine in the sample oxidised the I− ions to I2

•        The iodine was titrated with sodium thiosulfate (Na2S2O3) solution.

•        These steps were repeated using further samples taken from the vase water at hourly intervals.

(a)     Suggest **two** reasons why the concentration of chlorine in the vase water decreases with time.

Reason 1 ........................................................................................................

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Reason 2 ........................................................................................................

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**(2)**

(b)     Suggest why this sampling technique has no effect on the rate at which the concentration of chlorine in the vase water decreases.

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**(1)**

(c)     Why was it important to use an **excess** of potassium iodide solution?

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**(1)**

(d)     Use the following standard electrode potential data to explain why I2 oxidises S2O32− under standard conditions.

 + e−    I−                         = +0.54 V

 + e−    S2O32−                = +0.09 V

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**(1)**

(e)     Deduce an ionic equation for the reaction between I2 and S2O32−

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**(1)**

**(Total 6 marks)**

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| **12.** |  | |
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|  |  | **(Total 14 marks)** |