| | |
|---|---|
| **Student Number** | |
| **Mark / 39** | |

# Chemistry

**Preliminary Course**

**Final Examination • 2006**

**General Instructions**

- Reading time – 5 minutes
- Working time – 45 minutes
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A Data Sheet and a Periodic Table are provided
- Write your Student Number at the top of this page

**Total Marks – 39**

**Part A – 10 marks**
- Attempt Questions 1 – 10
- Allow about 10 minutes for this part

**Part B – 29 marks**
- Attempt Questions 11 – 19
- Allow about 35 minutes for this part

**Part A – 10 marks**
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Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

**Sample:** 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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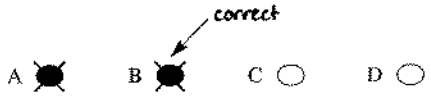


| Answer Box for Questions 1 – 10 | | | | |
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► ***Mark your answers for Questions 1 – 10 in the Answer Box on page 2.***

---

**1** The law of combining volumes states that the ratio of gases involved in a chemical reaction can be expressed in simple whole number ratios.

Identify who proposed this law*?*

(A) Dalton
(B) Gay–Lussac
(C) Avogadro
(D) Mendeleev

**2** Which statement is correct for $NO_2$ gas*?*

(A) One molecule has a mass of 46 g.
(B) One molecule occupies a volume of 24.79 L at 0°C and 100 kPa.
(C) One mole contains $6.02 \times 10^{23}$ atoms of oxygen.
(D) One mole contains $6.02 \times 10^{23}$ molecules.

**3** The extraction of a metal from its ore involves a series of steps as shown…

mine ore → concentrate ore → extract metal via smelting → purify the metal

Which chemical equation represents a reaction that would be appropriate for the metal extraction step for copper from its ore*?*

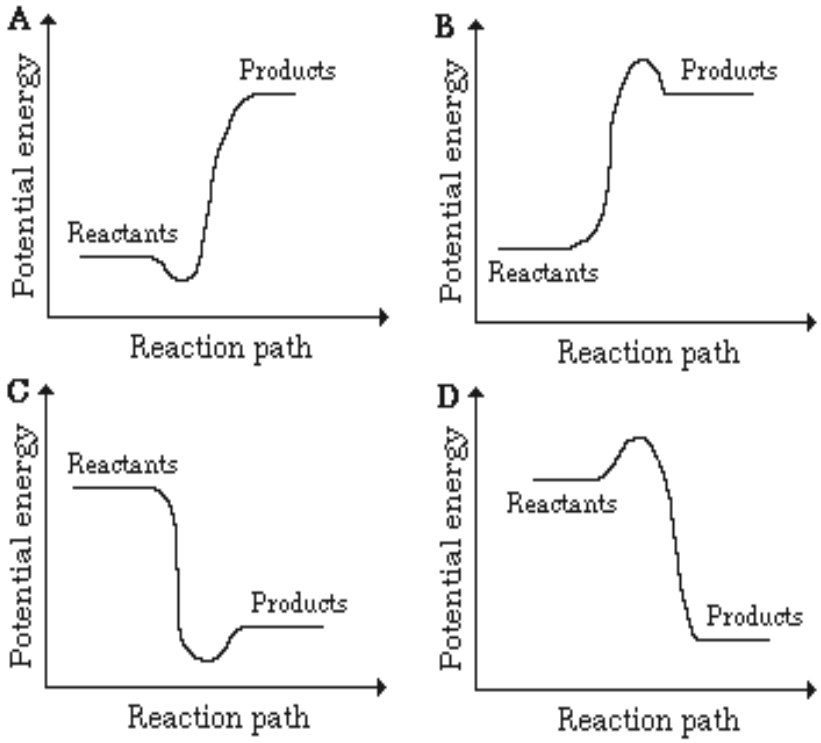
(A) $FeO\,(s) + SiO_2\,(s) \rightarrow FeSiO_3\,(l)$
(B) $2CuFeS_2\,(s) + 5O_2\,(g) \rightarrow 2Cu\,(l) + 2FeO\,(s) + 4SO_2\,(g)$
(C) $Cu \rightarrow Cu^{2+} + 2e^-$
(D) $CuO\,(s) + Mg\,(s) \rightarrow MgO\,(s) + Cu\,(s)$

**4** Which of these processes is endothermic*?*

(A) decomposition of silver chloride to silver and chlorine
(B) burning methane
(C) condensing steam
(D) adding sodium metal to water

**5** Which graph represents the change in potential energy for the reaction…

$$2NO_2\,(g) \rightarrow N_2\,(g) + 2\,O_2\,(g) \qquad \Delta H = +33.7 \text{ kJ mol}^{-1}$$




(A) Graph A
(B) Graph B
(C) Graph C
(D) Graph D

**6** A compound contains potassium, sulfur and oxygen only. A sample of the compound is found to contain 41.1 mg of potassium, 33.8 mg of sulfur and 25.2 mg of oxygen.

Which of the following represents the empirical formula of the compound?

(A) $K_2SO_4$
(B) $K_2SO_3$
(C) $K_2S_2O_3$
(D) $K_2SO_2$

**7** In a calorimeter, a 1.000 g sample of magnesium is burned to form MgO, and in so doing, releases 6.075 kJ of energy. What is the heat of combustion, in kJ, of one mole of magnesium?

(A) 6.075
(B) 72.90
(C) 147.7
(D) $3.65 \times 10^{25}$

**8** 10 mL of hydrogen fluoride gas reacts with 5 mL of dinitrogen difluoride gas to form 10 mL of a gas. All gas volumes are measured at the same temperature and pressure.

Which of the following is the most likely equation for the reaction?

(A) $HF\ (g) + N_2F_2\ (g) \rightarrow N_2HF_3\ (g)$
(B) $2HF\ (g) + N_2F_2\ (g) \rightarrow N_2H_2F_4\ (g)$
(C) $2HF\ (g) + N_2F_2\ (g) \rightarrow 2NHF_2\ (g)$
(D) $HF\ (g) + 2N_2F_2\ (g) \rightarrow N_4HF_5\ (g)$

**9** The table shows the solubility of salts in water at 25°C.

| ANION | CATION | COMPOUND |
|---|---|---|
| All | Group I metals | soluble |
| All | Ammonium, $NH_4^+$ | soluble |
| Nitrate, $NO_3^-$ | All | soluble |
| Acetate/ethanoate $CH_3COO^-$ | All except $Ag^+$ | soluble |
| Chloride, $Cl^-$<br>Bromide, $Br^-$<br>Iodide, $I^-$ | $Ag^+$, $Pb^{2+}$, $Hg_2^{2+}$, $Cu^+$ | insoluble |
| | All others | soluble |
| Sulfate, $SO_4^{2-}$ | $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Pb^{2+}$, $Ag^+$, $Hg_2^{2+}$ | insoluble |
| | All others | soluble |
| Sulfide, $S^{2-}$ | Group I and II metals, $NH_4^+$ | soluble |
| | All others | insoluble |
| Hydroxide, $OH^-$ | Group I metals, $NH_4^+$, $Sr^{2+}$, $Ba^{2+}$ | soluble |
| | All others | insoluble |
| Carbonate, $CO_3^{2-}$<br>Phosphate, $PO_4^{3-}$<br>Sulfite, $SO_3^{2-}$ | Group I metals, $NH_4^+$ | soluble |
| | All others | insoluble |

A student mixed several salt solutions as described in the table.

| *Mixture number* | *Salt solutions mixed* |
|---|---|
| 1 | sodium sulfate + magnesium nitrate |
| 2 | sodium chloride + magnesium iodide |
| 3 | calcium nitrate + ammonium sulfate |

In which mixture(s) will a precipitate occur?

(A) 1 only
(B) 1 and 3
(C) 1 and 2
(D) 3 only

**10** A single piece of zinc was put into 2 mol $L^{-1}$ hydrochloric acid. It was observed that the rate of production of hydrogen gas soon reached a maximum and then decreased.

The following reasons were put forward for the decrease in the rate of formation of hydrogen…

I The concentration of the acid decreased as the reaction proceeded.
II The surface area of the zinc decreased as the reaction proceeded.
III The reaction was exothermic.

Which of the above three suggestions explains the decreasing reaction rate?

(A) I, II and III
(B) I and II only
(C) I only
(D) II only

**Part B – 29 marks**
**Attempt Questions 11 – 19**
**Allow about 35 minutes for this part**

► ***Show all relevant working in questions involving calculations.***

---

**Question 11 (2 marks)**

Describe the energy changes involved in the dissolving of copper(II) sulfate crystals in water.

_____

_____

_____

**Question 12 ( 3 marks)**

During a chemical reaction, chemical bonds are broken and then reformed.

(a) Outline the role of activation energy in this process. **(1 mark)**

_____

_____

_____

(b) Compare the overall energy involved in breaking and reforming bonds in the combustion of methane. (**2 marks)**

_____

_____

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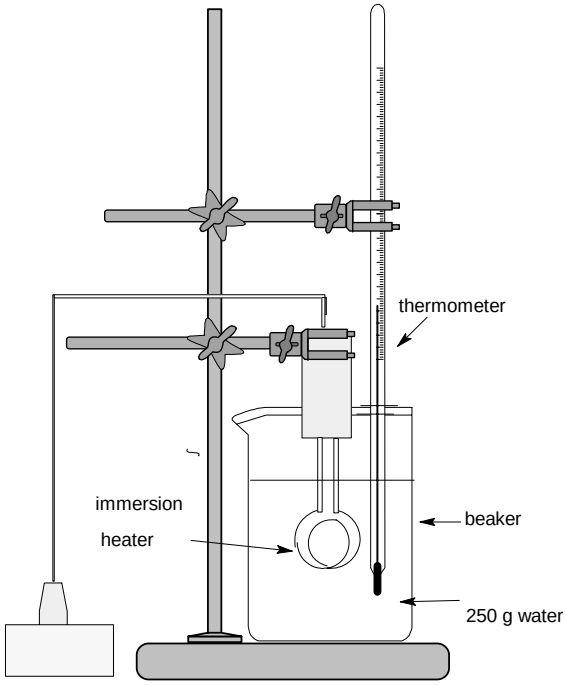
**Question 13 (6 marks)**

A group of students were assigned to verify the value of the specific heat capacity of water.
The diagram shows their experimental set–up…



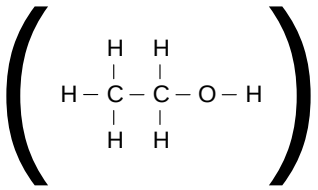

The immersion heater provided 75.7 kJ of heat which raised the temperature of the water in the beaker from 25°C to 85°C.

(a) Calculate the experimental value of the specific heat capacity of water. **(2 marks)**

(b) Compare the experimental value calculated above with the reference value for the specific heat of water. Explain any difference in the values. **(2 marks)**

(c) Outline ways to improve the experimental set-up to obtain a more valid result. **(2 marks)**

**Question 14 (2 marks)**

Explain why ethanol  totally dissolves in water. **(2 marks)**

_____

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**Question 15 (4 marks)**

Identify the molecular shapes and draw the Lewis electron dot structures of water and hydrogen sulfide.

_____

| | |
|---|---|
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Hydrogen gas can be generated by reacting an acid with an active metal.

(a) Write an equation for the reaction between magnesium and hydrochloric acid. **(1 mark)**

(b) Calculate the volume of hydrogen gas generated at 25°C and 100 kPa when 4.86 g of magnesium are reacted with excess 1.00 mol $L^{-1}$ hydrochloric acid. **(2 marks)**

**Question 17 (2 marks)**

Lead is a toxic heavy metal that is carefully monitored in waterways.

An electric probe measured the concentration of lead ions ($Pb^{2+}$) in a creek as 0.07 ppm.

Calculate the mass of lead ions that would be found in 3 L of the creek water.

**Question 18 (3 marks)**

A student prepared a sugar solution by dissolving 1.71 g of sucrose ($C_{12}H_{22}O_{11}$) in water and making the volume up to 100 mL.

(a) Calculate the concentration of the sucrose solution in moles per litre. **(2 marks)**

(b) The student then diluted the sucrose solution to 250 mL.

Calculate the concentration of the new sucrose solution in moles per litre. **(1 mark)**

**Question 19 (4 marks)**

$BaSO_4$ is frequently used as a radiocontrast agent for X-ray imaging. It can be prepared using precipitation reactions.

2.08 g of barium chloride was dissolved in water to make 50 mL of solution and then added to 50 mL of a solution containing 2.84 g of sodium sulfate. A white precipitate formed.

(a) Write a net ionic equation for the reaction forming the precipitate. **(1 mark)**

(b) What is the mass of the precipitate formed? **(2 marks)**

(c) Calculate the concentration, in moles per litre, of the sulfate ions in the final solution. **(1 mark)**

**Answers**
**and**
**Marking Scheme**

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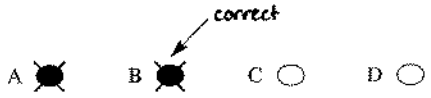


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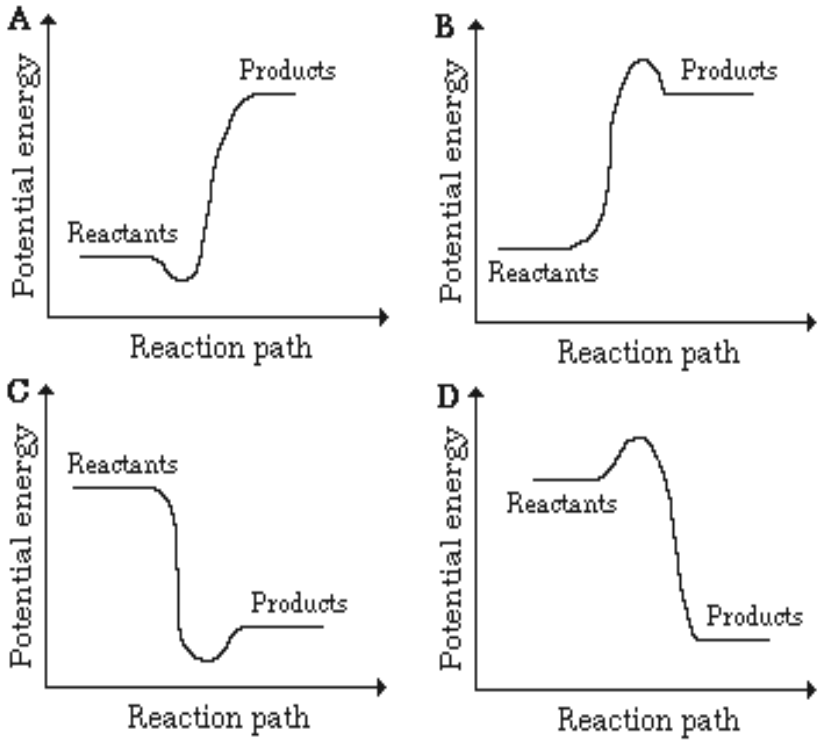


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| Sulfide, $S^{2-}$ | Group I and II metals, $NH_4^+$ | soluble |
| | All others | insoluble |
| Hydroxide, $OH^-$ | Group I metals, $NH_4^+$, $Sr^{2+}$, $Ba^{2+}$ | soluble |
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| Carbonate, $CO_3^{2-}$<br>Phosphate, $PO_4^{3-}$<br>Sulfite, $SO_3^{2-}$ | Group I metals, $NH_4^+$ | soluble |
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**10** A single piece of zinc was put into 2 mol $L^{-1}$ hydrochloric acid. It was observed that the rate of production of hydrogen gas soon reached a maximum and then decreased.

The following reasons were put forward for the decrease in the rate of formation of hydrogen…

I The concentration of the acid decreased as the reaction proceeded.
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III The reaction was exothermic.

Which of the above three suggestions explains the decreasing reaction rate?

(A) I, II and III
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(C) I only
(D) II only

**Part B – 29 marks**
**Attempt Questions 11 – 19**
**Allow about 35 minutes for this part**

► ***Show all relevant working in questions involving calculations.***

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**Question 11 (2 marks)**

Describe the energy changes involved in the dissolving of copper(II) sulfate crystals in water.

***When copper(II) sulfate dissolves in water…***

- ***The electrostatic force of attraction between the copper ion and the sulfate ion breaks, the process requiring energy. (1 mark)***

- ***The copper and the sulfate ions are surrounded by water molecules releasing energy. (1 mark)***

**Question 12 ( 3 marks)**

During a chemical reaction, chemical bonds are broken and then reformed.

(a) Outline the role of activation energy in this process. **(1 mark)**

***The activation energy provides energy needed to break bonds.***

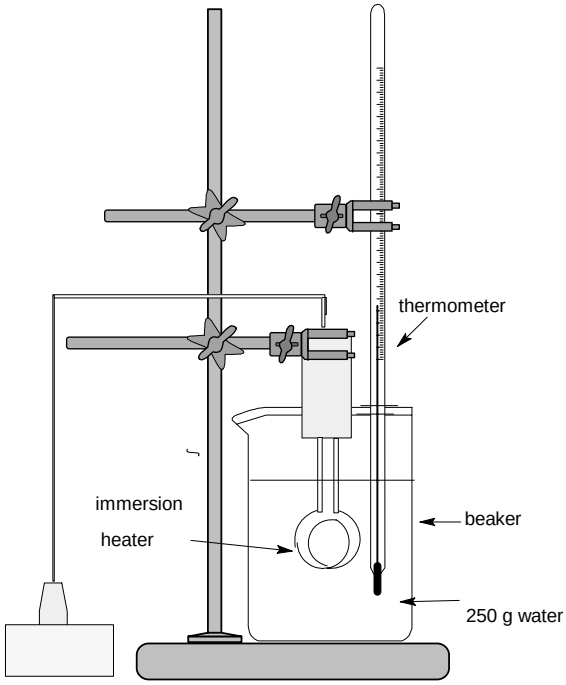
(b) Compare the overall energy involved in breaking and reforming bonds in the combustion of methane. (**2 marks)**

***The combustion of methane is an exothermic reaction, therefore the total energy required in breaking the bonds in methane and oxygen is less than the total energy released in forming the bonds in water and carbon dioxide.***

***1 mark for saying it was exothermic***
***1 mark for the explanation***

**Question 13 (6 marks)**

A group of students were assigned to verify the value of the specific heat capacity of water.
The diagram shows their experimental set–up…




The immersion heater provided 75.7 kJ of heat which raised the temperature of the water in the beaker from 25°C to 85°C.

(a) Calculate the experimental value of the specific heat capacity of water. **(2 marks)**

$\Delta H = - mc\Delta T$

$$c = \frac{-\Delta H}{-m\Delta T} = \frac{-75700}{-250\ x\ (85-25)} = 5.1\ J/K-g$$

(b) Compare the experimental value calculated above with the reference value for the specific heat of water. Explain any difference in the values. **(2 marks)**

***The experimental value is higher (5.1) than the standard value (4.18). This indicates that the heat supplied did not all directly transferred to the water, that is, heat was lost in the process.***
***This is seen by the fact that a greater amount of heat was apparently required to raise the temperature of a unit amount of water by 1 K.***

***Comparison (1 mark)***
***Explanation (1 mark)***

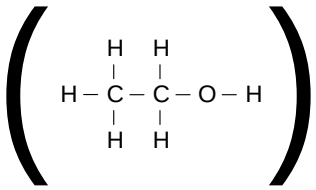
(c) Outline ways to improve the experimental set-up to obtain a more valid result. **(2 marks)**

***The validity of the experiment can be improved by preventing the escape of heat.***

- ***change the beaker to a styrofoam cup (styrofoam insulates better than glass)***
- ***cover the beaker***
- ***stir the solution, so the heat is uniformly transferred throughout the whole bulk of the solution.***
- ***calibrate the glassware, i.e., determine how much heat the glassware absorbs and then apply the correction***

***Any 2 of the above modifications = 2 marks***

**Question 14 (2 marks)**

Explain why ethanol  totally dissolves in water. **(2 marks)**

***Both water and ethanol are polar molecules, having hydrogen bonds and dispersion forces acting in between their molecules. Hence ethanol dissolves in water.***

- ***Stating both water and ethanol polar molecules. (1)***
- ***Stating water and ethanol molecules can form hydrogen bonds with each other. (1)***

**Question 15 (4 marks)**

Identify the molecular shapes and draw the Lewis electron dot structures of water and hydrogen sulfide.

***The water molecule has a bent shape.*** ***(1)***

***The hydrogen sulfide molecule has a bent shape.*** ***(1)***

| | |
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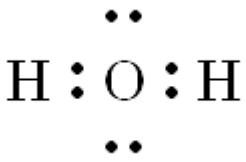
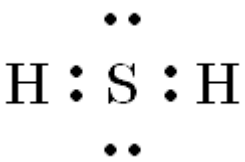
|  |  |
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**Question 16 (3 marks)**

Hydrogen gas can be generated by reacting an acid with an active metal.

(a) Write an equation for the reaction between magnesium and hydrochloric acid. **(1 mark)**

***$Mg + 2HCl \rightarrow MgCl_2 + H_2$***

(b) Calculate the volume of hydrogen gas generated at 25°C and 100 kPa when 4.86 g of magnesium are reacted with excess 1.00 mol $L^{-1}$ hydrochloric acid. **(2 marks)**

***mol Mg = $\frac{\text{mass}}{\text{formula weight}}$ = 4.86/24.3 = 0.2 mol***

***therefore mol $H_2$ = 0.2 mol***

***Volume $H_2$ = mol x 24.79L***

***= 4.96 L***

***Marking criteria*** ***Correct answer with relevant working. (2 marks)***

***Correct moles or incorrect moles correctly multiplied by 24.79. (1 mark)***

**Question 17 (2 marks)**

Lead is a toxic heavy metal that is carefully monitored in waterways.

An electric probe measured the concentration of lead ions ($Pb^{2+}$) in a creek as 0.07 ppm.

Calculate the mass of lead ions that would be found in 3 L of the creek water.

***0.07 ppm = 0.07 mg/L***

***3 × 0.07 mg in 3L = 0.21 mg in 3 L***

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***Answer left in mg/L (1 mark)***

**Question 18 (3 marks)**

A student prepared a sugar solution by dissolving 1.71 g of sucrose ($C_{12}H_{22}O_{11}$) in water and making the volume up to 100 mL.

(a) Calculate the concentration of the sucrose solution in moles per litre. **(2 marks)**

***mol sucrose = mass/fw = 1.71 / 342 = 0.005 mol***

***[sucrose] = mol/volume = 0.005 / 0.1 = 0.05 mol $L^{-1}$***

***Marking criteria*** *correct answer with relevant working (2 marks)*
*correct moles of sucrose or incorrect moles correctly divided by the volume (1)*

(b) The student then diluted the sucrose solution to 250 mL.

Calculate the concentration of the new sucrose solution in moles per litre. **(1 mark)**

***$c_1V_1 = c_2V_2$***
***$0.05 \times 0.1 = c_2 \times 0.250$***
***$c_2 = 0.02$ mol $L^{-1}$*** ***Marking criteria*** *~ correct answer with working (1 mark)*

**Question 19 (4 marks)**

$BaSO_4$ is frequently used as a radiocontrast agent for X-ray imaging. It can be prepared using precipitation reactions.

2.08 g of barium chloride was dissolved in water to make 50 mL of solution and then added to 50 mL of a solution containing 2.84 g of sodium sulfate. A white precipitate formed.

(a) Write a net ionic equation for the reaction forming the precipitate. **(1 mark)**

***$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$*** *(must include states )*

(b) What is the mass of the precipitate formed? **(2 marks)**

***mol $BaCl_2$ = 2.08 / 208 = 0.0100 mol***

***mol $Na_2SO_4$ = 2.84 / 141.95 = 0.02 mol (therefore sulfate is in excess)***

***mol $BaSO_4$ = 0.01***

***mass $BaSO_4$ = mol × fw = 0.01 × 233.37 = 2.33 g***

***Marking criteria*** *correct answer with relevant working (2 marks)*

*correct mol $BaCl_2$, $Na_2SO_4$ or fw of $BaSO_4$ (1 mark)*

(c) Calculate the concentration, in moles per litre, of the sulfate ions in the final solution. **(1 mark)**

***$[SO_4^{2-}]$ = unreacted mol/total volume = 0.02 – 0.01 / 0.05 + 0.05 = 0.01 / 0.1***

***= 0.1 mol $L^{-1}$*** *(1 mark)*