



James Ruse Agricultural High School

Theory

Year 11 Preliminary Chemistry Exam 2014

General Instructions

- **Reading Time:** 5 minutes
- **Working Time:** 50 minutes
- Write using black or blue pen
- Board approved calculators may be used
- Write your Student Number at the top of page 9
- A Periodic Table and Data sheet are provided

Total Marks 46

Attempt Questions 1-12

A  B  C  D 

correct (arrow pointing to B)

▶ Mark your answers for Questions 1 – 12 in the Answer Box on page 9

1. Which is the correct quantity for 0.080 g of sulfur trioxide gas?
- (A) 6.0×10^{21} atoms of oxygen
 - (B) 1.8×10^{22} atoms of sulfur
 - (C) 1.0×10^{21} molecules of gas
 - (D) 6.0×10^{21} atoms of sulfur
2. 0.02 mol of metal M reacts with 0.03 mol of oxygen atoms to give compound X and with 0.04 mol oxygen atoms to give compound Y.
- What could be the formula for compound X and Y respectively?
- (A) M_3O_2 and M_2O
 - (B) M_2O_3 and MO_2
 - (C) MO and M_2O
 - (D) M_2O_3 and M_2O_5
3. A 5.0 g sample of methane occupies a volume of 10.0 L. Under the same conditions of temperature and pressure, what volume would 5.0 g of sulfur dioxide occupy?
- (A) 2.5 L
 - (B) 5.0 L
 - (C) 10.0 L
 - (D) 40.0 L

4. Why is petrol in an open drum a hazard?

- (A) It has a high ignition temperature.
- (B) It is both volatile and flammable.
- (C) It produces a large amount of energy during combustion.
- (D) Poisonous carbon monoxide forms when it is exposed to oxygen.

5. Which represents an empirical formula?

- (A) H_2O_2
- (B) C_4H_6
- (C) C_3H_8
- (D) N_2O_4

6. Water dissolves different substances in different ways.

Which of the following most correctly identifies a solute and the process by which it dissolves in water?

- (A) Sucrose dissolves by dissociation.
- (B) HCl (hydrogen chloride) dissolves by ionisation.
- (C) NaCl (sodium chloride) dissolves by ionisation.
- (D) Sucrose dissolves by means of the dispersion forces that it forms with the water molecules.

7. The following image illustrates a phenomenon associated with the nature of the water molecule.

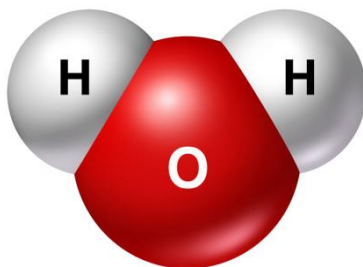
What is the name of this phenomenon?



Source: <http://thevoiceofonecryingoutinthewilderness.blogspot.com.au>

- (A) Density
 - (B) Viscosity
 - (C) Capillarity
 - (D) Surface tension
8. How many moles of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ are needed to prepare 2.50 L of 0.300 mol L^{-1} solution?
- (A) 0.750 mol
 - (B) 1.20 mol
 - (C) 8.33 mol
 - (D) 0.430 mol

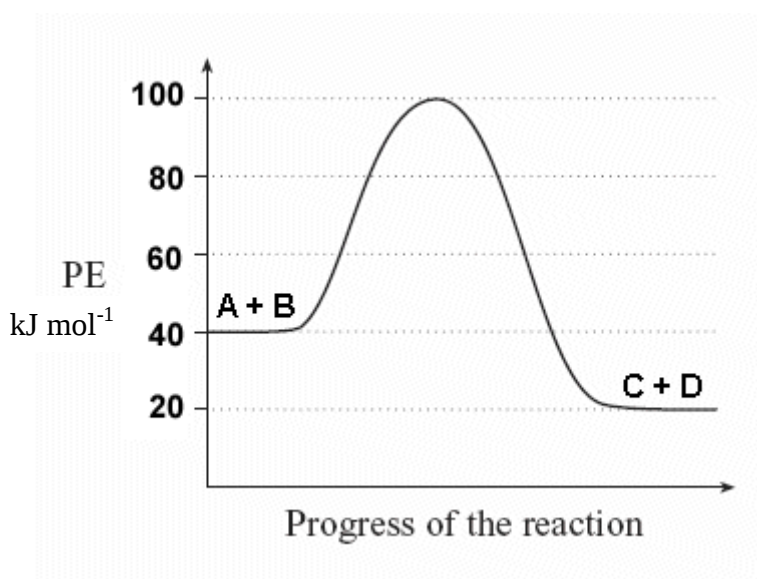
9. The following diagram shows one way of modeling a water molecule.



What is the number of unshared pairs of electrons on the central atom in this molecule?

- (A) one
 - (B) two
 - (C) three
 - (D) four
10. At room temperature, F_2 and Cl_2 are gases, Br_2 is a liquid, and I_2 is a solid. Which of the following is the explanation for these differences?
- (A) dipole- dipole interactions increase with molecular size
 - (B) polarity increases with molecular size
 - (C) dispersion forces increase with molecular size
 - (D) dispersion forces and polarity increase with molecular size.

11. The energy pathway for the reaction $A + B \rightarrow C + D$ is represented by the graph.



What is the magnitude and sign of ΔH in the reaction?

- (A) $+ 60 \text{ kJ mol}^{-1}$
(B) $+ 40 \text{ kJ mol}^{-1}$
(C) $- 20 \text{ kJ mol}^{-1}$
(D) $- 40 \text{ kJ mol}^{-1}$
12. Which is the best representation of photosynthesis?
- (A) $6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g})$
(B) $6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) + \text{light}$
(C) $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) + \text{light} \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$
(D) $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) + \text{light}$

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Student No.

Total Mark

Part A: Answer grid for multiple choice questions

- | | | | | |
|-----|-------------------------|-------------------------|-------------------------|-------------------------|
| 1. | A ☐ | B ☐ | C ☐ | D ☐ |
| 2. | A ☐ | B ☐ | C ☐ | D ☐ |
| 3. | A ☐ | B ☐ | C ☐ | D ☐ |
| 4. | A ☐ | B ☐ | C ☐ | D ☐ |
| 5. | A ☐ | B ☐ | C ☐ | D ☐ |
| 6. | A ☐ | B ☐ | C ☐ | D ☐ |
| 7. | A ☐ | B ☐ | C ☐ | D ☐ |
| 8. | A ☐ | B ☐ | C ☐ | D ☐ |
| 9. | A ☐ | B ☐ | C ☐ | D ☐ |
| 10. | A ☐ | B ☐ | C ☐ | D ☐ |
| 11. | A ☐ | B ☐ | C ☐ | D ☐ |
| 12. | A ☐ | B ☐ | C ☐ | D ☐ |

Part B. 34 marks

Attempt Questions 13- 22

Allow about 40 minutes for this part

► Show all relevant working in questions involving calculations.

Question 13 (4 marks)

- (a) Name an industrial catalyst and identify the chemical reaction for which it is used. (2 marks)

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- (b) Explain the action of catalysts in chemical reactions. (2 marks)

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Question 14 (4 marks)

Hydrogen can be prepared in the laboratory by the action of hydrochloric acid on zinc.

- (a) Write a balanced chemical equation for the reaction of hydrochloric acid with zinc. (1 mark)

.....

- (b) In an experiment conducted at 25⁰C and 100 kPa, 2.25 L of hydrogen was collected.

Calculate the mass of zinc which reacted with the hydrochloric acid. (3 marks)

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Question 15 (5 marks)

Explain, with the aid of a diagram, why the boiling point of water is unusually high compared to other molecules of similar size and mass.



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Question 16 (3 marks)

A student is asked to make a solution of magnesium nitrate $\text{Mg}(\text{NO}_3)_2$. She dissolved 50.00 g of magnesium nitrate to make 150.0 mL of solution.

Calculate the molarity of the solution she has made.

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Question 17 (3 marks)

A sodium hydroxide solution and a copper (II) sulfate solution, when combined, produce solid copper (II) hydroxide.

- (a) Write a balanced chemical formula equation to represent this reaction.

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- (b) Construct a complete ionic equation to represent this reaction.

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- (c) Construct a net ionic equation to represent this reaction.

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Question 18 (2 marks)

- (a) Which one of the following molecules would be most polar : H_2 , HCl , HBr , HI , or HF ?

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- (b) Explain your answer in (a).

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Question 19 (2 marks)

A river water sample has a concentration of $2.04 \times 10^{-4} \text{ mol L}^{-1}$ of mercury.

What is the concentration of mercury in parts per million (ppm)?

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Question 20 (5 marks)

- (a) What is meant by the term *thermal pollution*? (1 mark)

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- (b) Describe two implications for aquatic life in a water body affected by thermal pollution. (4 marks)

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Question 21 (3 marks)

Instant hot packs used to treat sporting injuries often contain a saturated solution of sodium acetate (ethanoate) and a plastic bag of water. When a disc of iron is flexed (bent) in the bag, it causes the immediate precipitation of the sodium acetate.

- (a) Is this reaction exothermic or endothermic? Justify your answer. (1 mark)

.....

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- (b) Give an equation for the dissolution of sodium acetate (ethanoate), including heat as a reactant or product. (2 marks)

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Question 22 (3 marks)

The molar heat of solution of sodium hydroxide is 44.5 kJ mol^{-1} .

Calculate the mass of sodium hydroxide required to raise the temperature of 100.0 g of water by 2.66°C

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End of Theory Test

Part A: Answer grid for multiple choice questions

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|-----|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| 1. | A ☐ | B ☐ | C ☐ | D ☐ |
| 2. | A ☐ | B ☒ | C ☐ | D ☐ |
| 3. | A ☒ | B ☐ | C ☐ | D ☐ |
| 4. | A ☐ | B ☒ | C ☐ | D ☐ |
| 5. | A ☐ | B ☐ | C ☒ | D ☐ |
| 6. | A ☐ | B ☒ | C ☐ | D ☐ |
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| 8. | A ☒ | B ☐ | C ☐ | D ☐ |
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1. Which is the correct quantity for 0.080 g of sulfur trioxide gas?
- (A) 6.0×10^{21} atoms of oxygen
 - (B) 1.8×10^{22} atoms of sulfur
 - (C) 1.0×10^{21} molecules of gas
 - (D) 6.0×10^{21} atoms of sulfur**

Outcomes : P10

2. 0.02 mol of metal M reacts with 0.03 mol of oxygen atoms to give compound X and with 0.04 mol oxygen atoms to give compound Y.
- What could be the formula for compound X and Y respectively?
- (A) M_3O_2 and M_2O
 - (B) M_2O_3 and MO_2**
 - (C) MO and M_2O
 - (D) M_2O_3 and M_2O_5

Outcomes : P6, P10

3. A 5.0 g sample of methane occupies a volume of 10.0 L. Under the same conditions of temperature and pressure, what volume would 5.0 g of sulfur dioxide occupy?
- (A) 2.5 L**
 - (B) 5.0 L
 - (C) 10.0 L
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Outcomes : P10

4. Why is petrol in an open drum a hazard?
- (A) It has a high ignition temperature.
 - (B) It is both volatile and flammable.**
 - (C) It produces a large amount of energy during combustion
 - (D) Poisonous carbon monoxide forms when it is exposed to oxygen.

Outcomes : P9

5. Which represents an empirical formula?
- (A) H_2O_2
 - (B) C_4H_6
 - (C) C_3H_8**
 - (D) N_2O_4

Outcomes : P10

6. Water dissolves different substances in different ways.
- Which of the following most correctly identifies a solute and the process by which it dissolves in water?
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Outcomes : P

7. The following image illustrates a phenomenon associated with the nature of the water molecule.

What is the name of this phenomenon?



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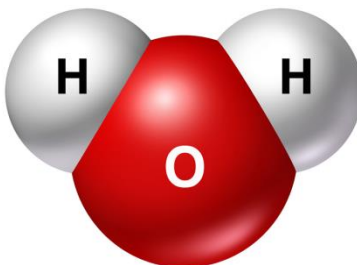
- (A) Density
- (B) Viscosity
- (C) Capillarity
- (D) Surface tension**

Outcomes : P

8. How many moles of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ are needed to prepare 2.50 L of 0.300 mol L^{-1} solution?
- (A) 0.750 mol**
 - (B) 1.20 mol
 - (C) 8.33 mol
 - (D) 0.430 mol

Outcomes : P

9. The following diagram shows one way of modeling a water molecule.



What is the number of unshared pairs of electron on the central atom in this molecule?

- (A) one
- (B) two**
- (C) three
- (D) four

Outcomes : P

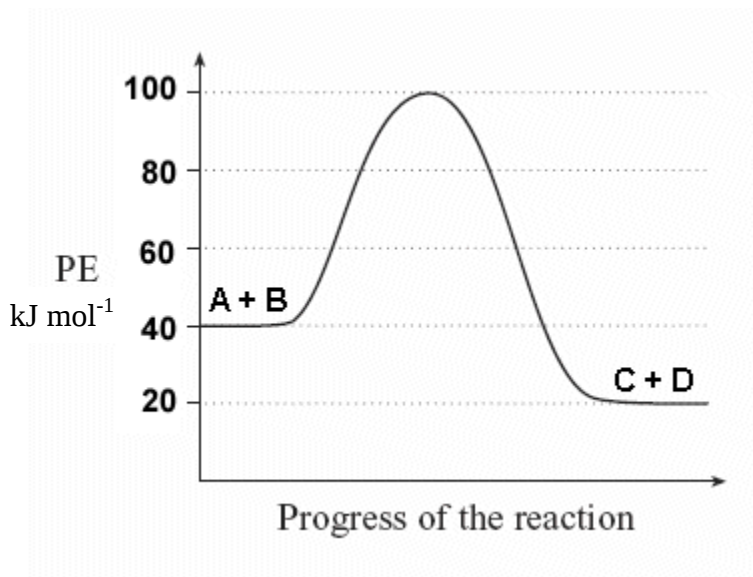
10. At room temperature, F_2 and Cl_2 are gases, Br_2 is a liquid, and I_2 is a solid.

Which of the following is the explanation for these differences?

- (A) Dipole- dipole interactions increase with molecular size.
- (B) Polarity increases with molecular size
- (C) Dispersion forces increase with molecular size**
- (D) Dispersion forces and polarity increase with molecular size.

Outcomes : P

11. The energy pathway for the reaction $A + B \rightarrow C + D$ is represented by the graph.



What is the magnitude and sign of ΔH in the reaction?

- (A) $+ 60 \text{ kJ mol}^{-1}$
- (B) $+ 40 \text{ kJ mol}^{-1}$
- (C) $- 20 \text{ kJ mol}^{-1}$
- (D) $- 40 \text{ kJ mol}^{-1}$

Outcomes : P7, P8

12. Which is the best representation of photosynthesis?

- (A) $6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g})$
- (B) $6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) + \text{light}$
- (C) $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) + \text{light} \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$
- (D) $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) + \text{light}$

Outcomes : P7, P9

Question 13 (4 marks)

- (a) Name an industrial catalyst and identify the chemical reaction for which it is used. (2 marks)

Sample Answer : iron in the Haber process or production of ammonia or vanadium pentoxide in the Contact process or production of sulfuric acid (various acceptable answers)

Outcomes : P7, P8

- (b) Explain the action of catalysts in chemical reactions. (2 marks)

Sample Answer : A catalyst lowers the activation energy required to in a chemical reaction by providing an alternate pathway for the reaction and thus saves energy in the production process.

Criteria	Marks
Correct industrial catalyst and process	2
One only	1
Correct explanation of how catalyst works	2
Outline of how catalysts work	1

Outcomes : P7**Question 14 (4 marks)**

Hydrogen can be prepared in the laboratory by the action of hydrochloric acid on zinc.

- (a) Write a balanced chemical equation for the reaction of hydrochloric acid with zinc.
(1mark)
- (b) In an experiment conducted at 25⁰C and 100 kPa room temperature and pressure, 2.25 L of hydrogen was collected.

Calculate the mass of zinc which reacted with the hydrochloric acid. (3 marks)

Sample Answer :



b) Moles of $\text{H}_2 = 2.25\text{L} / 24.79 = 0.0907 \text{ mol}$

From Eqn 1 mol Zn = 1 mol H_2

Thus 0.0907 mol Zn

Thus Mass of Zn = $0.0907 \times 65.38 \text{ g.mol}^{-1} = 5.93 \text{ g}$

Marking Scheme

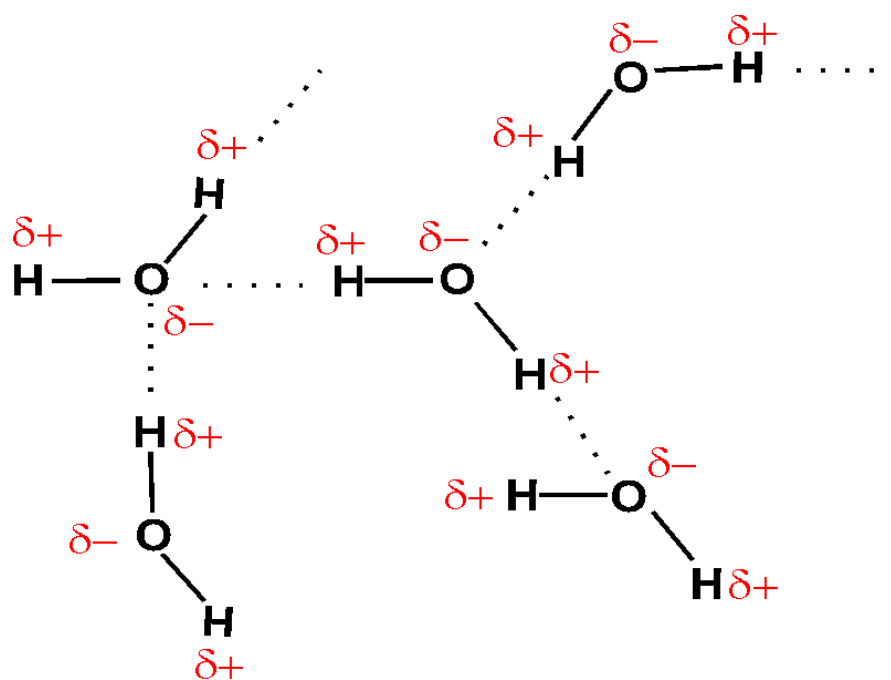
Criteria	Marks
a) Correct balanced equation	2
Correct equation not balanced	1
b) Correct calculation with units	3
One error in calculation	2
Two errors in calculation	1

Outcomes : P8, P10

Question 15 (5 marks)

Explain, with the aid of a diagram, why the boiling point of water is unusually high compared to other molecules of similar size and mass.

Sample answer:



The high boiling point of water is due to the hydrogen bonds which hold the water molecules together. Thus requiring a large amount of kinetic energy to separate the water molecules and form water vapour. Other molecules of similar size and mass do not have the structure that allows this to happen.

Answer	Marks Allocated
Two water molecules correctly drawn AND Gives a correct description of the formation of hydrogen bonds.AND Relates this to the strength of the intermolecular force. (strongest intermolecular force)AND Relates this to the need for increased energy needed for the change of state. AND Makes an appropriate statement that refers to the difference between water molecules and other compounds of approximately the same mass and size.	5 marks
Two water molecules correctly drawn AND Gives a correct description of the formation of hydrogen bonds.AND Relates this to the strength of the intermolecular force. (strongest intermolecular force)AND Relates this to the need for increased energy needed for the change of state. OR Two water molecules correctly drawn AND Gives a correct description of the formation of hydrogen bonds.AND Relates this to the strength of the intermolecular force. (strongest intermolecular force)AND Makes an appropriate statement that refers to the difference between water molecules and other compounds of approximately the same mass and size.	4 marks
Two water molecules correctly drawn AND Gives a correct description of the formation of hydrogen bonds.AND Relates this to the strength of the intermolecular force. (strongest intermolecular force)	

OR One water molecule correctly drawn AND Notes that water molecules are held together by intermolecular bonds.AND Identifies these as hydrogen bonds OR Two water molecules correctly drawn but hydrogen bonds not illustrated. AND Gives a clear description of hydrogen bonds.AND Identifies these as the strongest intermolecular force.	3 marks
One water molecule correctly drawn AND Gives a correct description of the formation of hydrogen bonds. OR One water molecule correctly drawn AND Notes that water molecules are held together by intermolecular bonds. OR Two water molecules correctly drawn but hydrogen bonds not illustrated.	2 marks
One water molecule drawn OR No diagram but gives a correct description of the formation of hydrogen bonds. OR No diagram but notes that water molecules are held together by intermolecular bonds.	1 mark

Question 16 (3 marks)

A student is asked to make a solution of magnesium nitrate $\text{Mg}(\text{NO}_3)_2$. She dissolved 50.00 g of magnesium nitrate to make 150.0 mL of solution.

Calculate the molarity of the solution she has made.

Molecular mass of magnesium nitrate:

Magnesium: 24.305g

Nitrogen x 2: 28.02g

Oxygen x 6: 96.0g

Molecular mass of magnesium nitrate: $148.325 \text{ g mol}^{-1}$ **1 mark**

$50 \text{ g Mg}(\text{NO}_3)_2 \quad n = \frac{50}{148.325} \text{ mol}$

$n = 0.337 \text{ mol}$ **1 mark**

Molarity = $\frac{0.337}{0.150} \text{ mol L}^{-1}$

0.150

Molarity = 2.246 mol L^{-1} **1 mark**

Outcomes : P**Question 17** (3 marks)

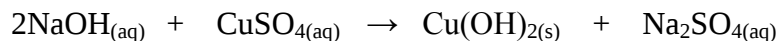
A sodium hydroxide solution and a copper (II) sulfate solution, when combined, produce solid Copper(II) hydroxide.

- (a) Write a balanced chemical formula equation to represent this reaction.
- (b) Construct a complete ionic equation to represent this reaction.
- (c) Construct a net ionic equation to represent this reaction.

NB: Normally I would only have 1 mark for an equation BUT I have set aside 2 marks for each equation because each tests a couple of points. Appropriate for this place in the chem. Course.

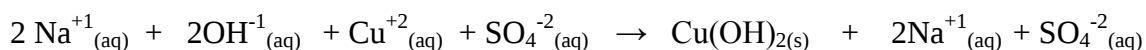
- Reactions that involve precipitates.....
- Construct ionic equations.....

(a) **Write an appropriate balanced chemical equation to represent this reaction.**



Balanced chemical equation (1 mark)

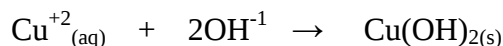
(b) **Construct a total ionic equation to represent this reaction.**



Shows all ions appropriately (1 mark)

Shows solid formed appropriately (1 mark)

(b) **Construct a net ionic equation to represent this reaction.**



Recognises and omits all spectator ions (1 mark)

Outcomes : P

Question 18 (2 marks)

(a) Which one of the following molecules would be most polar, H_2 , HCl , HBr , HI , or HF ?

HF

(b) Explain your answer in (a).

The difference in electronegativities is greatest between hydrogen and Fluorine and therefore the bond between them is the most polar.

Outcomes : P6

Question 19 (2 marks)

A river water sample has a concentration of $2.04 \times 10^{-4} \text{ mol L}^{-1}$ of mercury. What is the concentration of mercury in parts per million (ppm)?

$$\begin{aligned}
 & 2.04 \times 10^{-4} \text{ mol / L} \\
 = & 2.04 \times 10^{-4} \times 200.6 \text{ g / L} & (1 \text{ mark}) \\
 = & 0.0409 \times 1000 \text{ mg / L} \\
 = & 40.92 \text{ mg / L} \\
 = & 40.92 \text{ ppm} & (1 \text{ mark})
 \end{aligned}$$

Outcomes : P4, P10

Question 20 (5 marks)

- (a) What is meant by the term *thermal pollution*?

Thermal pollution occurs when excess heat is discharged into the environment (1 mark)

- (b) Describe two implications for aquatic life in a water body affected by thermal pollution.

Sample answer

Thermal pollution can cause the water to have less dissolved oxygen which can be fatal to fish and other aquatic organisms. Fish also have higher metabolic rates in hotter water and require more oxygen which has been depleted. Higher water temperatures can also trigger early migration or spawning in fish at the wrong time of year, causing disruption to breeding cycles.

Marking Criteria	Mark(s)
<i>Describes two implications to aquatic life.</i>	4
<i>Describes one implications to aquatic life AND Outlines one implication to aquatic life</i>	3
<i>Identifies two implications to aquatic life.</i>	2
<i>Identifies one implication to aquatic life.</i>	1

Outcomes: P4

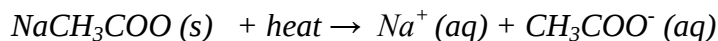
Question 21 (3 marks)

Instant hot packs used to treat sporting injuries often contain a saturated solution of sodium acetate (ethanoate) and a plastic bag of water. When a disc of iron is flexed (bent) in the bag it causes the immediate **precipitation** of the sodium acetate.

- (a) Is this reaction exothermic or endothermic? Justify your answer. (1 mark)

This reaction is exothermic as the pack gets hotter (heat is released)

- (b) Give an equation for the **dissolution** of sodium acetate (ethanoate), including heat as a reactant or product. (2 marks)



1 mark for balanced equation 1 mark for the inclusion of heat

Outcomes: P7

Question 22 (3 marks)

The molar heat of solution of sodium hydroxide is 44.5 kJ mol^{-1} .

Calculate the mass of sodium hydroxide required to raise the temperature of 100.0g of water by 2.66°C

$$\Delta H = -m C \Delta T$$

$$= -100 \times 4.18 \times 2.66$$

$$= -1112 \text{ J} \quad (1 \text{ mark})$$

$$\text{Molar mass NaOH} = 22.99 + 16 + 1 = 40 \text{ g} \quad (1 \text{ mark})$$

1 mole NaOH, 40 g releases 44,500 J

Therefore x g releases 1112 J

$$x = 1112 \times 40 / 44500$$

$$= 1.00 \text{ g} \quad (1 \text{ mark})$$