



James Ruse Agricultural High School

Theory

Year 11 Preliminary Chemistry Exam 2015

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 8
- A Periodic Table and Data sheet are provided

Total Marks : 46

Part A

Multiple Choice: 10 marks

Attempt Questions 1-10

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
 A ☐ B ☒ C ☐ D ☐

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ☒ B ☒ C ☐ D ☐

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

A ☒ B ☒ C ☐ D ☐
 correct
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► Mark your answers for Questions 1 – 10 in the Answer Box on page 7

1. Which of the following describes the specific heat capacity of a substance?
- (A) It is the amount of heat per unit mass required to raise the temperature of the substance by one degree Celsius.
- (B) It is the amount of heat required to overcome the activation energy of any substance allowing it to react with another substance.
- (C) It is the molar heat of combustion of that substance.
- (D) It is the amount of heat per unit mass required to change the temperature of the substance compared with the specific heat capacity of water used as a standard.
2. To which of the following chemical reactions does Gay-Lussac's law apply?
- (A) $2\text{H}_2\text{O}(l) \rightarrow 2\text{H}_2(g) + \text{O}_2(g)$
- (B) $\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)$
- (C) $\text{CO}_2(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{CO}_3(aq)$
- (D) $2\text{C}_3\text{H}_7\text{OH}(l) + 9\text{O}_2(g) \rightarrow 8\text{H}_2\text{O}(g) + 6\text{CO}_2(g)$
3. Which of the following is NOT a chemical reaction?
- (A) Methane gas is produced in the digestive process of cows.
- (B) Bubbles are observed when magnesium is placed in acid.
- (C) Bubbles are observed when a sugar cube is placed in water.
- (D) A yellow precipitate forms when lead nitrate is added to sodium iodide.
4. Which of the alternatives correctly describes the reaction below?
- $$\text{H}_2\text{O}(g) + \text{CO}(g) \rightarrow \text{H}_2(g) + \text{CO}_2(g) + \text{energy}$$

	<i>Exothermic or endothermic</i>	ΔH
(A)	Exothermic	+
(B)	Exothermic	—
(C)	Endothermic	+
(D)	Endothermic	—

5. Why does water have a higher boiling point than hydrogen fluoride?
- (A) Water forms more extensive hydrogen bonds than hydrogen fluoride.
- (B) The covalent bond between O and H is stronger than that between F and H.
- (C) Water is less polar than hydrogen fluoride.
- (D) Water is more polar than hydrogen fluoride.
6. A solution of potassium hydroxide contains 0.500 mole of KOH in 250 mL of solution.
- What is the concentration of this solution?
- (A) 0.125 mol L⁻¹
- (B) 2.00 mol L⁻¹
- (C) 6.25 mol L⁻¹
- (D) 12.5 mol L⁻¹
7. An extract from a list of solubilities of some common ionic compounds is given below:

	<i>Soluble</i>	<i>Insoluble</i>
Nitrates	All	
Chlorides	Most	AgCl, PbCl ₂
Sulfates	Most	BaSO ₄ , PbSO ₄
Hydroxides	NaOH, KOH, NH ₄ OH	

When hydrochloric acid was added to a solution containing two metal ions, a precipitate formed with one ion but the other ion remained soluble.

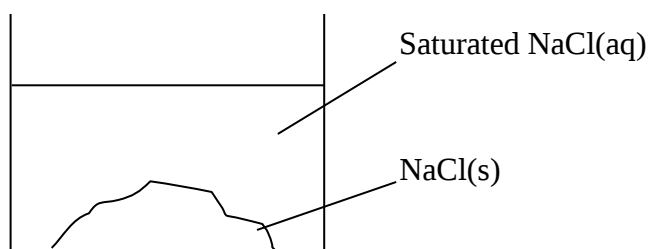
Which of the following ions could the solution contain?

- (A) Ag⁺ and Cu²⁺
- (B) Cu²⁺ and Ni²⁺
- (C) Ag⁺ and Pb²⁺
- (D) Ba²⁺ and Ni²⁺

8. Consider the three compounds: sodium carbonate, Na_2CO_3 , calcium carbonate, CaCO_3 and iron(II) carbonate, FeCO_3 .

Which statement is correct with respect to the percent by mass of oxygen in each compound?

- (A) All have the same percent by mass of oxygen.
- (B) Na_2CO_3 has the greater percent by mass of oxygen.
- (C) CaCO_3 has the greater percent by mass of oxygen.
- (D) FeCO_3 has the greater percent by mass of oxygen.
9. Refer to the diagram below to answer the following question.



The system above consists of a saturated salt solution with some undissolved salt crystals. Which statement correctly describes the point of equilibrium?

- (A) Both dissolution and precipitation have stopped.
- (B) The rate of dissolution is greater than the rate of precipitation.
- (C) The rate of dissolution is less than the rate of precipitation.
- (D) Both dissolution and precipitation are occurring at an equal rate.
10. How many nitrate ions are in solution when 0.01 mol of vanadyl nitrate, $\text{VO}(\text{NO}_3)_3$, is dissolved in water ?
- (A) 0.03
- (B) 0.09
- (C) 0.54×10^{23}
- (D) 0.18×10^{23}

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Student No.

Total Mark

Part A

Multiple Choice Answer Sheet

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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 ☐ |
| 7. | A ☐ | B ☐ | C ☐ | D ☐ |
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| 9. | A ☐ | B ☐ | C ☐ | D ☐ |
| 10. | A ☐ | B ☐ | C ☐ | D ☐ |

Part B. 36 marks

Attempt questions 11 - 18

Allow about 40 minutes for this part

► Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response

► Show all relevant working in questions involving calculations

Question 11 (6 marks)

(a) Explain the action of catalysts in chemical reactions.

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(b) Draw the energy profile of an exothermic reaction showing the pathway without a catalyst **AND** with a catalyst in the space below.

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Question 12 (5 marks)

A student weighed a specific amount of magnesium chlorate (chlorate ion is ClO_3^-). It was heated and decomposed to magnesium chloride and oxygen gas.

The student aims to produce 52 mL of oxygen when the gas is cooled to 25°C and 100 kPa.

- (a) Write a balanced chemical equation for the decomposition of magnesium chlorate, including states. 1

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- (b) Calculate the number of moles of oxygen the student is aiming to produce. 1

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- (c) Calculate the mass of magnesium chlorate the student measured. 1

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- (d) The student found that when all the magnesium chlorate was thought to be decomposed, less than 52 mL of oxygen was produced.

If the percentage yield of the reaction is 83%, then how much magnesium chlorate must the student weigh to produce a volume of 52 mL of oxygen? 2

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Question 13 (2 marks)

In the case of solid or liquid fuels, identify ONE factor other than use of a catalyst, that can be changed to make an explosive reaction. Justify your choice.

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Question 14 (4 marks)

The element carbon forms a variety of compounds.

Properties for some carbon compounds are described in the table below.

<i>Substance</i>	<i>Melting point</i>	<i>Boiling Point</i>	<i>Solubility in Water</i>
Methane CH ₄	Low	Low	Insoluble
Ethanol C ₂ H ₅ OH	Low	Low	Good
Sodium carbonate Na ₂ CO ₃	High	High	Good

- (a) Explain the difference between the solubility of methane and ethanol in water. 2

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- (b) Describe what happens when solid sodium carbonate dissolves in water, include an equation in your answer. 2

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Question 15 (4 marks)

(a) Draw the structural formula of ammonia showing the shape of the molecule. 2

(b) Account for the shape of the ammonia molecule. 2

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Question 16 (4 marks)

An organic compound, on analysis, was found to contain 59.4% by mass of fluorine, 37.5% by mass of carbon and 3.1% by mass of hydrogen.

(a) Calculate the empirical formula of the compound. 3

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(b) Determine the molecular formula of the compound given it has a molar mass of 64.0 g. 1

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Question 17 (5 marks)

A student added excess sodium sulfate solution to 25.00 mL of the Pb^{2+} solution to determine the concentration of lead ions in solution. The precipitate was filtered and analysed. After drying the precipitate had a mass of 1.137 g.

- (a) Write a net ionic equation for the precipitation reaction. 1

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- (b) Calculate the concentration of lead ions in the solution in moles per litre. 2

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- (c) Calculate the concentration of lead ions in grams per 100 mL of solution. 2

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Question 18 (6 marks)

Solid calcium metal reacts with excess hydrochloric acid to produce a salt and a gas.

- (a) Write a balanced chemical equation for this reaction. Show all states. 2

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- (b) Calculate the volume of the gas that is formed at room temperature and pressure when 3.0 g of calcium is dissolved in excess hydrochloric acid? 2

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- (c) In a second experiment involving an unknown mass of calcium, 0.75 L of the gas was produced at room temperature and pressure.

Calculate the concentration of 425 mL of hydrochloric acid that reacted to produce this volume of the gas.

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End of Theory Exam



James Ruse Agricultural High School

Theory

With Answers

Year 11 Preliminary Chemistry Exam 2015

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Attempt Questions 1-10

A  B  C  D 

correct (arrow pointing to B)

Page 2

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(B) It is the amount of heat required to overcome the activation energy of any substance allowing it to react with another substance.

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(B) $\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)$

(C) $\text{CO}_2(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{CO}_3(aq)$

(D) $2\text{C}_3\text{H}_7\text{OH}(l) + 9\text{O}_2(g) \rightarrow 8\text{H}_2\text{O}(g) + 6\text{CO}_2(g)$

3. Which of the following is NOT a chemical reaction?

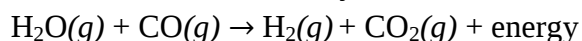
(A) Methane gas is produced in the digestive process of cows.

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7. An extract from a list of solubilities of some common ionic compounds is given below:

<i>Test anions</i>	<i>Soluble</i>	<i>Insoluble</i>
Nitrates	All	
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Sulfates	Most	BaSO ₄ , PbSO ₄
Hydroxides	NaOH, KOH, NH ₄ OH	

When hydrochloric acid was added to a solution containing two metal ions, a precipitate formed with one ion but the other ion remained soluble.

Which of the following ions could the solution contain?

(A) Ag^+ and Cu^{2+}

(B) Cu^{2+} and Ni^{2+}

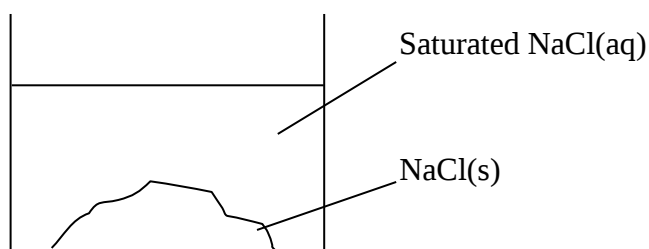
(C) Ag^+ and Pb^{2+}

(D) Ba^{2+} and Ni^{2+}

8. Consider the three compounds: sodium carbonate, Na_2CO_3 , calcium carbonate, CaCO_3 and iron(II) carbonate, FeCO_3 .

Which statement is correct with respect to the percent by mass of oxygen in each compound?

- (A) All have the same percent by mass of oxygen.
- (B) Na_2CO_3 has the greater percent by mass of oxygen.
- (C) CaCO_3 has the greater percent by mass of oxygen.**
- (D) FeCO_3 has the greater percent by mass of oxygen.
9. Refer to the diagram below to answer the following question.



The system above consists of a saturated salt solution with some undissolved salt crystals. Which statement correctly describes the point of equilibrium?

- (A) Both dissolution and precipitation have stopped.
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- (C) 0.54×10^{23}
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Student No.

Total Mark

Part A

Multiple Choice Answer Sheet

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|-----|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| 1. | A ☒ | B ☐ | C ☐ | D ☐ |
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Part B. 36 marks

Attempt questions 11 - 18

Allow about 40 minutes for this part

► Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response

► Show all relevant working in questions involving calculations

Question 11 (6 marks)

(a) Explain the action of catalysts in chemical reactions.

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Sample Answer :

- *Reduces the activation energy,*
- *hence a greater number of particle collisions will have the required amount of energy to react (OR the particles involved in the collisions will have the required amount of energy to react)*
/aids the alignment of reactant molecules
/weakens the bonds in reactant
/stabilises transition states
*/ thus **greater number of successful collisions***
- *Increases the reaction rate*

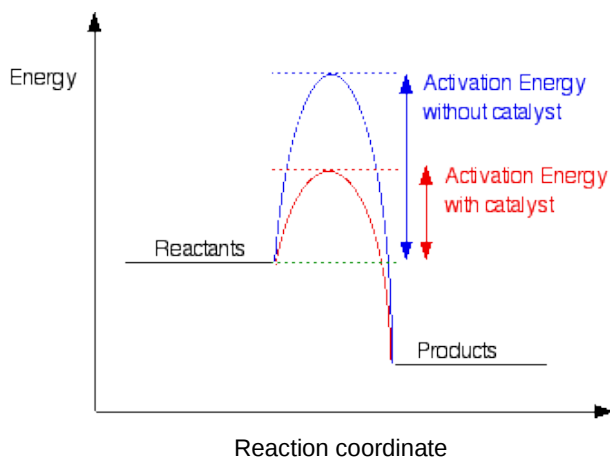
Marking Criteria	Marks
• Catalysts REDUCES the activation energy • Identifies that more particle collisions will result in a chemical reaction • Catalysts INCREASES the reaction rate	3
• TWO of any points made above	2
• ONE of any points made above	1

- (b) Draw a labelled diagram for the energy profile of an exothermic reaction without a catalyst **AND** with a catalyst in the space below.

3



Sample Answer :



Marking Criteria	Marks
- The energy of the products is less than the reactants: EXOTHERMIC - A large hump: activation energy WITHOUT a catalyst AND A smaller hump: activation energy WITH a catalyst (catalysts REDUCES the activation energy) - Both curves begin and end at the same energy level as each other, the energy of the reactants and products remain the same	3
TWO of any points made above	2
ONE of any points made above	1

Question 12 (5 marks)

A student weighed a specific amount of magnesium chlorate (chlorate ion is ClO_3^-). It was heated and decomposed to magnesium chloride and oxygen gas.

The student aims to produce 52 mL of oxygen when the gas is cooled to 25°C and 100 kPa.

- (a) Write a balanced chemical equation for the decomposition of magnesium chlorate, including states. 1

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- (b) Calculate the number of moles of oxygen the student is aiming to produce. 1

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- (c) Calculate the mass of magnesium chlorate that reacted and was measured by the student. 1

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- (d) The student found that when all the magnesium chlorate was thought to be decomposed, less than 52 mL of oxygen was produced.

If the percentage yield of the reaction is 83%, then how much magnesium chlorate must the student weigh to produce a volume of 52 mL of oxygen? 2

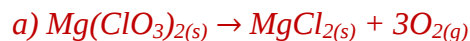
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Sample answers ;



Marking Criteria	Marks
Correct BALANCED chemical formulae AND STATES	1

*b) $V(\text{O}_2) = 0.052 \text{ L}$
 $n(\text{O}_2) = 0.052 \div 24.79$
 $= 2.098 \times 10^{-3} \text{ OR}$
 $= 2.1 \times 10^{-3} \text{ mol}$*

Marking Criteria	Marks
Correct number of moles (significant figures was not marked)	1

*c) $n(\text{Mg}(\text{ClO}_3)_2) = 0.7 \times 10^{-3} \text{ mol}$
 $m(\text{Mg}(\text{ClO}_3)_2) = (0.7 \times 10^{-3}) \times (24.31 + 2 \times 35.45 + 6 \times 16)$
 $= 0.13 \text{ g}$*

Marking Criteria	Marks
Correct mass (significant figures was not marked)	1

d) At 100% percentage yield, the experimental yield would be the same as the theoretical value.

Hence at a percentage yield of 83%, there needs to be $(2.1 \times 10^{-3}) \div 83 \times 100 = 2.5 \times 10^{-3}$ mol of oxygen (theoretical value) for 2.1×10^{-3} mol of oxygen (experimental yield).

Thus 0.84×10^{-3} mol of magnesium chlorate is needed, equalling 0.16 g.

(There are many different other ways to achieve the correct answer!)

Marking Criteria	Marks
- Defines experimental yield - Correct mass (significant figures was not marked)	2
Defines experimental yield	1

Question 13 (2 marks)

In the case of solid or liquid fuels, identify ONE factor other than use of a catalyst that can be changed to make an explosive reaction. Justify your choice.

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Sample Answer :

<i>Factor</i>	<i>Justification</i>
<i>Increasing surface area/ surface area to volume ratio</i>	<i>Increased number of effective collisions</i>
<i>Increasing the temperature</i>	
<i>Increasing the concentration of oxygen BUT NOT SO MUCH that the reagent is in EXCESS!</i>	

Marking Criteria	Marks
- Identifies a correct factor - Justification which corresponds to the chosen factor	2
Identifies a correct factor	1

Question 14 (4 marks)

The element carbon forms a variety of compounds.

Properties for some carbon compounds are described in the table below.

<i>Substance</i>	<i>Melting point</i>	<i>Boiling Point</i>	<i>Solubility in Water</i>
Methane CH ₄	Low	Low	Insoluble
Ethanol C ₂ H ₅ OH	Low	Low	Good
Sodium carbonate Na ₂ CO ₃	High	High	Good

(a) Explain the difference between the solubility of methane and ethanol in water.

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(b) Describe what happens when solid sodium carbonate dissolves in water, include an equation in your answer. 2

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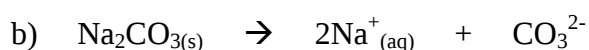
Sample Answer :

a) Methane = Is a non-polar molecular/covalent compound and water is a polar molecular/covalent compound.
Methane will not dissolve in water as is described by the concept of ‘like dissolves like’ a non-polar substance cannot dissolve in a polar liquid to produce a solution.

Ethanol = Is a polar molecular/covalent compound and water too is a polar covalent liquid at room temperature.

Ethanol will dissolve in water as is described by the concept of like dissolves like as both carry a degree of charge the methanol will dissolve in the liquid.

Marking Criteria	Marks
Clearly and thoroughly describes the differences in polarity of methane and methanol and compares these to water	2
Clearly and thoroughly describes the polarity of methane or methanol to water	1

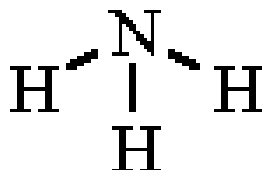


Sodium carbonate is an ionic solid, containing a positive metal ion and a negative non-metal ion. It will readily dissolve in water which is a polar covalent liquid and will break the electrostatic forces holding the opposite charges together.

Marking Criteria	Marks
Clearly displays the dissolving of sodium carbonate in water AND explains why sodium carbonate is soluble	2
Clearly displays the dissolving of sodium carbonate in water OR explains why sodium carbonate is soluble	1

Question 15 (4 marks)

- (a) Draw the structural formula of ammonia showing the shape of the molecule. 2



- (b) Account for the shape of the ammonia molecule. 2

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Sample Answer :

- a) ammonia shape = trigonal pyramid

Criteria	Mark
Correct structure and shape	2
Correct structure or shape	1

- b) Ammonia has a central nitrogen atom with one unshared pair of electrons at the apex and 3 shared pairs of electrons with hydrogen at the bases of a trigonal pyramid. The unshared pair of electrons has a stronger force of repulsion towards the 3 shared pairs than the 3 shared pairs exert on each other thus the unshared pair forces the 3 shared pairs further away from it, thus the pyramid shape.

A student added excess sodium sulfate solution to 25.00 mL of the Pb^{2+} solution to determine the concentration of lead ions in solution. The precipitate was filtered and analysed. After drying the precipitate had a mass of 1.137 g.

(a) Write a net ionic equation for the precipitation reaction. 1

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(b) Calculate the concentration of lead ions in the solution in moles per litre. 2

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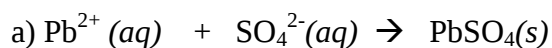
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(c) Calculate the concentration of lead ions in grams per 100 mL of solution. 2

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Sample Answer :



b) 1:1 mole ratio from equation above.

$$\text{PbSO}_4 = 1.137 \text{ g} \quad M = 303.26 \text{ g} \quad ; \quad \text{moles PbSO}_4 = 1.137 / 303.26 = 0.003749 \text{ mol}$$

$$\text{Concentration} = 0.003749 / 0.025 = 0.14996 \text{ mol L}^{-1}$$

c) Mole ratio 1:1 from eqn thus Concentration of $\text{Pb}^{2+} = 0.14996 \text{ mol L}^{-1}$

thus 0.014996 mol per 100 mL

$$\text{Mass of Pb}^{2+} = 0.014996 \times \text{Mass of Pb (207.2)} = 3.107 \text{ g}$$

Criteria	Marks
a) Correct balanced net ionic equation	1
b) Correct calculation of concentration with correct units	2
One error or incorrect units	1
c) Correct calculation of mass of Pb^{2+} ions with correct units	2
One error or incorrect units	1

Question 18 (6 marks)

Solid calcium metal reacts with excess hydrochloric acid to produce a salt and a gas.

- (a) Write a balanced chemical equation for this reaction. Show all states. 2

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- (b) Calculate the volume of the gas that is formed at room temperature and pressure when 3.0 g of calcium is dissolved in excess hydrochloric acid? 2

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- (c) In a second experiment involving an unknown mass of calcium, 0.75 L of the gas was produced at room temperature and pressure.

Calculate the concentration of 425 mL of hydrochloric acid that reacted to produce this volume of the gas. 2

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Sample answer

Solid calcium metal reacts with excess hydrochloric acid to produce a salt and a gas.

- (a) Write a balanced chemical equation for this reaction. Show all subscripts



Calculate the volume of the gas that is formed when 3g of calcium is reacted with excess hydrochloric acid?

3g calcium = $3/40.08 = 0.075$ mol
from equation, 1 mol Ca produces 1 mol H₂

0.75 L Ca produces 0.075 mol H₂
volume H₂ = $0.075 \times 24.79 = 1.85553892$ L = 1.9L

- (b) In a second experiment involving an unknown mass of calcium, 0.75 L of the gas was produced. Calculate the molarity of 425 mL of hydrochloric acid that reacted to produce this volume of the gas.

$$\begin{aligned}\text{Moles (H}_2\text{)} &= \text{vol} / 24.79 \\ &= 0.75 / 24.79 \\ &= 0.03025413 \text{ moles hydrogen gas}\end{aligned}$$

From equation: $\text{HCl} : \text{H}_2$ 2 : 1

$$\begin{aligned}\text{Therefore HCl} &= 2 * 0.03025413 \\ &= 0.06050827 \text{ moles HCl}\end{aligned}$$

425mL HCl must contain 1.5 moles

$$\begin{aligned}\text{Therefore molarity HCl} &= n/V = 0.06050827/0.425\text{L} \\ &= 0.1423724 \text{ molL}^{-1}\end{aligned}$$

End of Theory Exam