

## Multiple-Choice Answer Sheet

**VCAA Number:** \_\_\_\_\_

Circle the correct answer.

If you make a mistake, cross out your answer clearly and circle the correct response.

There is one mark per question.

No marks will be deducted for incorrect answers.

No marks will be given if more than one answer is selected.

|                    |   |   |   |   |
|--------------------|---|---|---|---|
| <b>Question 1</b>  | A | B | C | D |
| <b>Question 2</b>  | A | B | C | D |
| <b>Question 3</b>  | A | B | C | D |
| <b>Question 4</b>  | A | B | C | D |
| <b>Question 5</b>  | A | B | C | D |
| <b>Question 6</b>  | A | B | C | D |
| <b>Question 7</b>  | A | B | C | D |
| <b>Question 8</b>  | A | B | C | D |
| <b>Question 9</b>  | A | B | C | D |
| <b>Question 10</b> | A | B | C | D |
| <b>Question 11</b> | A | B | C | D |
| <b>Question 12</b> | A | B | C | D |
| <b>Question 13</b> | A | B | C | D |
| <b>Question 14</b> | A | B | C | D |
| <b>Question 15</b> | A | B | C | D |
| <b>Question 16</b> | A | B | C | D |
| <b>Question 17</b> | A | B | C | D |
| <b>Question 18</b> | A | B | C | D |
| <b>Question 19</b> | A | B | C | D |
| <b>Question 20</b> | A | B | C | D |

## Marking Sheet: 2013 Chemistry Unit 2 Exam

Name: \_\_\_\_\_

| Section / Question | Available Marks | Marks Attained |
|--------------------|-----------------|----------------|
| Multiple Choice    | 20              |                |
| 1                  | 8               |                |
| 2                  | 8               |                |
| 3                  | 4               |                |
| 4                  | 4               |                |
| 5                  | 6               |                |
| 6                  | 4               |                |
| 7                  | 5               |                |
| 8                  | 5               |                |
| 9                  | 2               |                |
| 10                 | 5               |                |
| 11                 | 6               |                |
| 12                 | 10              |                |

**Total Marks Available: 87**

**Marks Attained:**

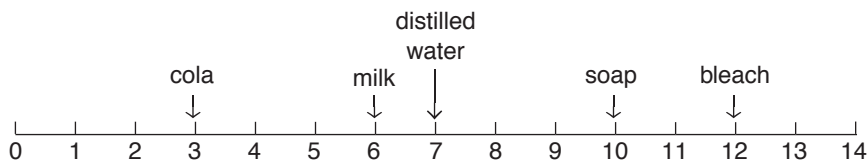
**Comments:**

## Multiple Choice Section

All answers MUST BE MARKED on the Answer Sheet. Answers given in the question booklet WILL NOT BE MARKED.

### Question 1:

The pH of some household liquids at 25°C is shown on the scale below.



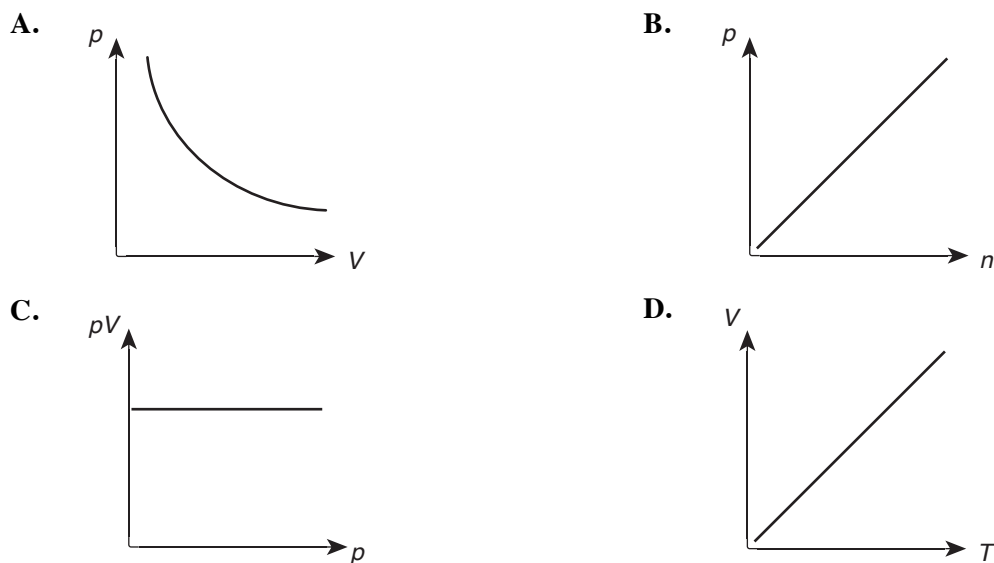
Which of the following statements concerning these liquids is incorrect?

- A. The hydrogen ion concentration in cola is 0.001 M.
- B. In the soap solution,  $[\text{H}_3\text{O}^+] < [\text{OH}^-]$ .
- C. Milk is  $10^6$  times more acidic than bleach.
- D. In distilled water,  $[\text{H}_3\text{O}^+]$  is  $10^{-7}$  M at any temperature.

### Question 2:

Which of the following graphs does not represent the behaviour of an ideal gas?

Note:  $V$  = volume (L);  $T$  = temperature ( $^{\circ}\text{C}$ );  $p$  = pressure (atm);  $n$  = number of mole (mol)



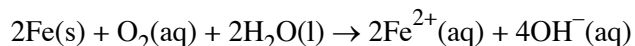
### Question 3:

Which of the following solutions contains the smallest amount (in mol) of hydronium ions?

- A. 10.0 mL of 0.3 M  $\text{HNO}_3$
- B. 10.0 mL of 0.3 M  $\text{H}_2\text{SO}_4$
- C. 30.0 mL of 0.1 M  $\text{HCl}$
- D. 30.0 mL of 0.1 M  $\text{CH}_3\text{COOH}$

**Question 4:**

A significant chemical reaction in the rusting of iron is shown in the equation:

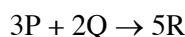


It can be deduced from this equation that

- A. both hydrogen and oxygen are reduced.
- B. oxygen causes reduction and undergoes oxidation.
- C. hydrogen is oxidised and iron is reduced.
- D. iron is the reductant and undergoes oxidation.

**Question 5:**

This question concerns the following chemical equation:



The minimum amount (in mol) of P which must be added to 1.50 mol of Q in order to produce exactly 3.00 mol of R is

- A. 1.65
- B. 1.80
- C. 2.25
- D. 2.40

**Question 6:**

Which one of the following chemical equations best represents the ionisation of the ethanoate ion,  $\text{CH}_3\text{COO}^-\text{(aq)}$ , a weak base, in water?

- A.  $\text{CH}_3\text{COO}^-\text{(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{CH}_3\text{COOH(aq)} + \text{OH}^-\text{(aq)}$
- B.  $\text{CH}_3\text{COO}^-\text{(aq)} + \text{OH}^-\text{(aq)} \rightarrow \text{CH}_3\text{COOH(aq)} + \text{O}^{2-}\text{(aq)}$
- C.  $\text{CH}_3\text{COO}^-\text{(aq)} + \text{H}_2\text{O(l)} \rightarrow \text{CH}_3\text{COOH(aq)} + \text{OH}^-\text{(aq)}$
- D.  $\text{CH}_3\text{COO}^-\text{(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{CH}_2\text{COO}^{2-}\text{(aq)} + \text{H}_3\text{O}^+\text{(aq)}$

**Question 7:**

When the volume of a gas sample in a piston is doubled without changing the temperature, the pressure exerted by the gas will

- A. increase to double the original pressure.
- B. be the same as the original pressure.
- C. decrease to half the original pressure.
- D. depend on the actual gas sample.

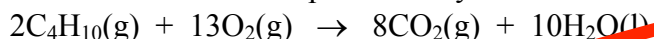
**Question 8:**

Which one of the following samples of gases would have the smallest volume at SLC?

- A.  $2 \times 10^{23}$  helium atoms.
- B. 22 g of carbon dioxide.
- C. 0.50 mol of argon atoms.
- D. 30 g of chlorine gas.

Question 9:

The complete combustion of butane can be represented by the chemical equation



What volume of carbon dioxide is produced when 1.5 L of butane is burnt and the reaction mixture brought back to the same temperature and pressure that the butane was initially measured at?

- A. 6.0 L
- B. 12.0 L
- C. 1.5 L
- D. 15.0 L

Question 10:

A base is **best** described as a substance that

- A. will neutralise an acid.
- B. can accept a proton.
- C. will turn red litmus indicator blue,
- D. can donate a proton.

Question 11:

In a redox reaction

- A. the reductant gains electrons and is oxidised.
- B. the oxidant loses electrons and is reduced.
- C. the reductant gains electrons and is reduced.
- D. the oxidant gains electrons and is reduced.

Question 12:

An amphiprotic substance is one that

- A. will donate more than one proton.
- B. can either accept or donate protons.
- C. will accept more than one proton.
- D. will neither accept or donate protons.

Question 13:

A beaker contains a saturated solution of copper(II) sulfate, together with some undissolved copper(II) sulfate.

Which of the following procedures would increase the concentration of the saturated solution?

- A. heating the mixture
- B. vigorously stirring the mixture
- C. adding more  $\text{CuSO}_4(\text{s})$  to the mixture
- D. adding water to the mixture

Question 14:

In which of the following reactions is the gaseous product different from that of the other three reactions?

- A. thermal decomposition of potassium chlorate ( $\text{KClO}_4$ )
- B. photosynthesis
- C. decomposition of hydrogen peroxide in the presence of a  $\text{MnO}_2$  catalyst
- D. incomplete combustion of methane

**Question 15:**

A 0.50 mol sample of nitrogen dioxide ( $\text{NO}_2$ ) has a volume of 7.0 L at a pressure of 3.0 atm.

The temperature of the  $\text{NO}_2$  sample is

- A. 5.0°C
- B. 239°C
- C. 512°C
- D. 785°C

**Question 16:**

An orange-coloured solution was prepared by dissolving 14.5 g of potassium dichromate ( $\text{K}_2\text{Cr}_2\text{O}_7$ ) in water and making up the volume to 100.0 mL with distilled water. This solution (solution I) was used to prepare three further solutions as outlined below.

solution II: 10 mL of solution I added to 30 mL of water

solution III: 20 mL of solution I made up to 50 mL with water

solution IV: 40 mL of solution I added to 30 mL of water

The concentrations of these three solutions increase in the order

- A. II, III, IV.
- B. III, II, IV.
- C. II, IV, III.
- D. IV, III, II.

**Question 17:**

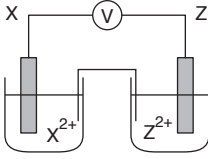
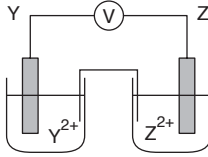
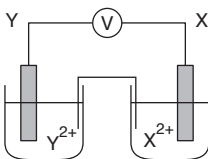
Which of the following unit conversions is **incorrect**?

- A.  $3.0 \text{ atm} = 2.3 \times 10^3 \text{ mmHg}$
- B.  $64 \text{ m}^3 = 6.4 \times 10^4 \text{ L}$
- C.  $-32^\circ\text{C} = 241 \text{ K}$
- D.  $620 \text{ mmHg} = 83 \text{ Pa}$

Question 18-20:

*Questions 18 to 20 relate to the following information.*

Two experiments were conducted using three metals identified by the symbols X, Y and Z. 1.0 M solutions of  $\text{XCl}_2$ ,  $\text{YCl}_2$  and  $\text{ZCl}_2$  were placed in each of three beakers. A strip of each metal was placed in the appropriate beaker to construct a half-cell. Half-cells were connected via wires, a voltmeter and a salt bridge containing  $\text{KNO}_3(\text{aq})$ . Three cells were constructed as shown below. For cells 1 and 2, the direction of electron flow and the cell voltage were recorded. Cell voltage provides an indication of the extent of reaction occurring. Results are shown below.

| Cell number | Cell structure                                                                      | Direction of electron flow | Cell voltage |
|-------------|-------------------------------------------------------------------------------------|----------------------------|--------------|
| 1           |    | from X to Z                | 0.31 V       |
| 2           |    | from Y to Z                | 0.10 V       |
| 3           |  | ?                          | ?            |

**Question 18**

In cell number 1, electrode Z is the

- A. positively charged cathode
- B. positively charged anode
- C. negatively charged cathode
- D. negatively charged anode.

**Question 19**

Which of the following represents the expected reaction occurring at the negative electrode in cell 3?

- A.  $\text{X}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{X}(\text{s})$
- B.  $\text{Y}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Y}(\text{s})$
- C.  $\text{X}(\text{s}) \rightarrow \text{X}^{2+}(\text{aq}) + 2\text{e}^-$
- D.  $\text{Y}(\text{s}) \rightarrow \text{Y}^{2+}(\text{aq}) + 2\text{e}^-$

**Question 20**

If metal X is identified as iron, and Z is identified as lead, then, with the aid of the electrochemical series, metal Y is possibly

- A. copper
- B. nickel
- C. calcium
- D. unable to be determined from the data provided

### Short-Answer Questions:

#### Question 1: 8 marks

A 5.25 g sample of hydrogen gas is held in a container at STP.

- a. Calculate the volume of the container.

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2 marks

- b. All of the hydrogen gas is pumped into another container of volume 25 L which already contains 0.301 mol of oxygen gas. The temperature of this container is raised to 250°C and held at this temperature throughout the experiment.

- i. Calculate the total gas pressure in the 25 L container.

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- ii. The gas mixture is ignited.

Write the balanced equation for the chemical reaction which occurs.

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- iii. Calculate the number of mole of gas in the mixture resulting from the reaction.

2 + 1 + 3 = 6 marks



**Question 2: 8 marks**

A student conducted electrical conductivity and pH tests on a range of aqueous solutions and pure water. The results are displayed in the table below.

| Substance                      | Electrical conductivity | pH at 25°C |
|--------------------------------|-------------------------|------------|
| pure water                     | very low                | 7.0        |
| 1.0 M HCl(aq)                  | high                    | 0          |
| 1.0 M CH <sub>3</sub> COOH(aq) | low                     | 2.7        |
| 1.0 M NH <sub>3</sub> (aq)     | low                     | 11.6       |

- a. Explain the very low electrical conductivity of pure water.

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1 mark

- b. Explain why the two acids in the table conduct electricity to different extents.

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2 marks

- c. Calculate the amount (in mol) of hydroxide ions in 250 mL of the 1.0 M NH<sub>3</sub> solution.

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3 marks

- d. The water molecule is amphoteric.

Using chemical equations, show that H<sub>2</sub>PO<sub>4</sub><sup>-</sup>(aq) is also amphoteric.

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2 marks

**Question 3: 4 marks**

- a. A 2.0 g sample of magnesium was added to a beaker of water. The mixture was warmed and reaction occurred according to the equation:



In this reaction, is the water acting as an acid, a base, an oxidant or a reductant?

Explain your choice.

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2 marks

- b. A 2.0 g sample of copper was added to a beaker of aqueous silver nitrate solution.

- i. What observations, if any, would you expect to make?

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- ii. Write a balanced chemical equation to account for the expected observations, or explain why no reaction would occur.

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1 + 1 = 2 marks

**Question 4: 4 marks**

- a. Sulfurous acid,  $\text{H}_2\text{SO}_3$ , is a weak diprotic acid. Write two appropriate chemical equations to describe the ionisation of this acid in aqueous solutions.

2 marks

- b. The pH of a 2 L sample of an aqueous solution is 4. What are the respective concentrations of the  $\text{H}_3\text{O}^+$ (aq) and  $\text{OH}^-$ (aq) ions in this solution?

2 marks

Question 5: 6 marks

a. A piece of copper wire is placed in an aqueous solution of silver nitrate.

i. Write the chemical half-equation for the reduction reaction that takes place.

1 mark

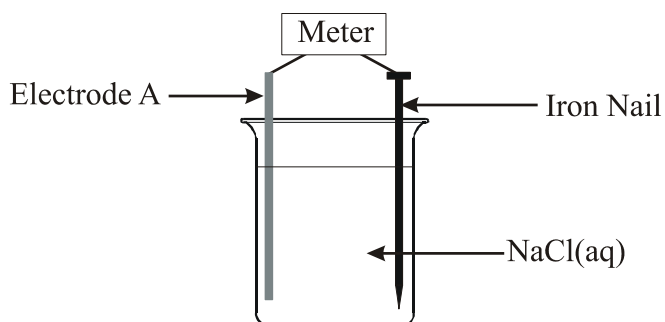
ii. Write the chemical half-equation for the oxidation reaction that takes place.

1 mark

iii. Write the overall chemical equation for the reaction that takes place.

1 mark

b. In an investigation of corrosion processes a group of students constructed a cell as shown in the diagram, using an iron nail for one electrode and different materials for the other electrode (labelled A). Complete the table below (circling the correct answer) to give the results that the students would be expected to obtain.



| Electrode A | Electrode at which oxidation occurs |                      |
|-------------|-------------------------------------|----------------------|
| i. Carbon   | Iron nail                           | Carbon (Electrode A) |
| ii. Zinc    | Iron nail                           | Zinc (Electrode A)   |
| iii. Copper | Iron nail                           | Copper (Electrode A) |

3 marks

Question 6: 4 marks

a.

A 4.85 g sample of a gas occupied a volume of 1.74 L at 351 K and 127 kPa.

i. How many mol of gas are present in this sample?

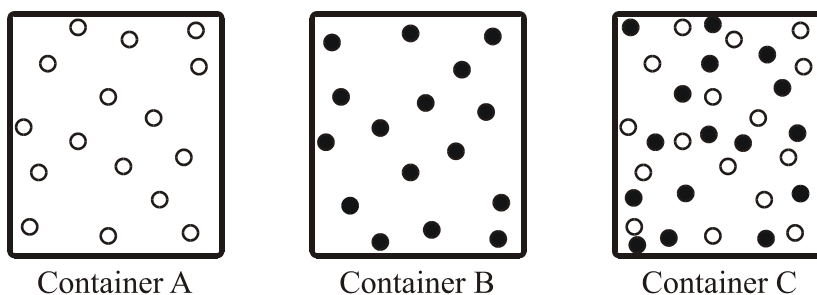
1 mark

ii. What is the molar mass for this gas?

1 mark

b.

The diagram below represents three containers of equal volume at the same temperature.



Containers A and B each hold different gases. The number of moles of gas in each container is the same.

Container C contains the combined contents of containers A and B.

i. What is the pressure of the gas in container B if the pressure of the gas in container A is 108 kPa?

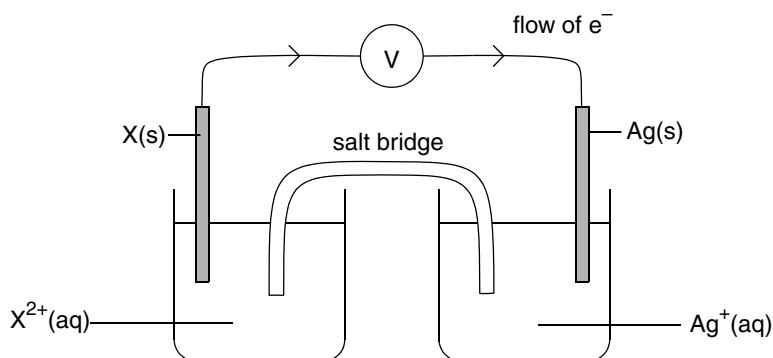
1 mark

ii. What is the pressure of the gases in container C?

1 mark

**Question 7: 5 marks**

A galvanic cell is formed by the combination of two half-cells:  $X^{2+}(aq)/X(s)$  and  $Ag^+(aq)/Ag(s)$ . When the cell is operating, the electron flow is as shown.



- a. i. Write a balanced ionic equation for the reaction occurring in the cell.
- \_\_\_\_\_
- ii. Which electrode (X or Ag) is the anode?
- \_\_\_\_\_
- iii. Which electrode (X or Ag) carries a positive charge?
- \_\_\_\_\_
- iv. In which direction (towards X or towards Ag) do cations move through the salt bridge?
- \_\_\_\_\_
- v. Give the formula for a substance that would be suitable for use in the salt bridge of this cell.
- \_\_\_\_\_

1 + 1 + 1 + 1 + 1 = 5 marks

Question 8: 5 marks

- a. The table below shows the relationship between properties of various samples of compounds or elements. Complete the table by indicating whether the quantity in the first column is greater than (>), less than (<) or equal to (=) the quantity in the second column. The first entry is completed as an example.

| Quantity 1                                                                                                         | >, < or = | Quantity 2                                                                                          |
|--------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------------------------------------|
| number of atoms of He in 1.0 mol of He                                                                             | =         | number of atoms of Ne in 1.0 mol of Ne                                                              |
| pH of an 0.10 M HCl solution                                                                                       |           | pH of an 0.10 M CH <sub>3</sub> COOH solution                                                       |
| volume of 0.20 M HNO <sub>3</sub> (a strong acid) required to completely react with 20.0 mL of 0.20 M KOH solution |           | volume of 0.20 M HCN (a weak acid) required to completely react with 20.0 mL of 0.20 M KOH solution |
| number of molecules of N <sub>2</sub> in 3.0 L of N <sub>2</sub> gas at 2.0 atm and 20°C                           |           | number of molecules of O <sub>2</sub> in 4.0 L of O <sub>2</sub> gas at 1.5 atm and 20°C            |

3 marks

- b. With the aid of the relevant calculations, explain the answer you gave in the last row of the table above.

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2 marks

Question 9: 2 marks

The label shown below is taken from a bottle of a carbonated apple drink.

**Ingredients**

Carbonated water, apple juice, sugar, glucose syrup, malic acid, preservative, artificial sweetener.

- a. Malic acid (C<sub>4</sub>H<sub>6</sub>O<sub>5</sub>) is added to improve the apple flavour of the drink. Malic acid is a *weak, diprotic acid*.

Explain what is meant by the term

- i. 'weak acid'.

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- ii. 'diprotic acid'.

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1 + 1 = 2 marks

**Question 10: 5 marks**

2.5 g (an excess) of iron (Fe) was added to 50.0 mL of 0.50 M sulfuric acid solution ( $\text{H}_2\text{SO}_4$ ). When the reaction was complete and all the hydrogen gas had bubbled out of the solution, the mixture of iron sulfate and unreacted iron was filtered to obtain the iron. When dried, the unreacted iron had a mass of 1.1 g.

**a.** Determine

**i.** the mass of iron that reacted with the sulfuric acid.

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**ii.** the amount (in mol) of iron that reacted with the sulfuric acid.

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**iii.** the amount (in mol) of sulfuric acid that reacted.

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1 + 1 + 1 = 3 marks

**b.** Using the values obtained in part **a**, write the balanced equation for the reaction. Hence determine the formula of the iron sulfate formed.

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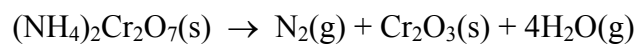
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2 marks

**Question 11: 6 marks**

A 0.630 g sample of ammonium dichromate,  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ , is decomposed by heating strongly.

Calculate the mass of water vapour formed when this sample of ammonium dichromate is decomposed. The chemical equation for the decomposition is



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The gas released from the decomposition is collected in a 250 mL syringe at 25 °C. Calculate the pressure (in kPa) of the collected gas.

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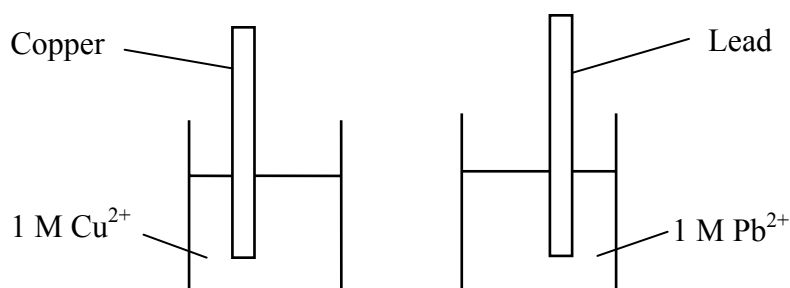
3 + 3 = 6 marks



Question 12: 10 marks

- a) Complete the diagram below to clearly show a galvanic cell that could be constructed from half cells containing the conjugate redox pairs  $\text{Cu}^{2+}/\text{Cu}$  and  $\text{Pb}^{2+}/\text{Pb}$ .

Clearly indicate the anode, the cathode, the polarity of the electrodes, the direction of flow of the electrons, the salt bridge, and the direction of flow of anions.



- b) Suggest a suitable solution for the salt bridge. \_\_\_\_\_
- c) Write ionic half equations and the overall equation for the reactions occurring in the galvanic cell.
- Oxidation: \_\_\_\_\_
- Reduction: \_\_\_\_\_
- Overall: \_\_\_\_\_
- d) Write the chemical formula of the oxidant in the galvanic cell. \_\_\_\_\_

(5 + 1 + 3 + 1 = 10 marks)