

Dot points that may be covered in the examination.

Measuring solubility and concentration

- solution concentration as a measure of the quantity of solute dissolved in a given mass or volume of solution (mol L^{-1} , g L^{-1} , $\%(m/v)$, $\%(v/v)$, ppm), including unit conversions
- the use of solubility tables and solubility graphs to predict experimental determination of ionic compound solubility; the effect of temperature on the solubility of a given solid, liquid or gas in water
- the use of precipitation reactions to remove impurities from water

Analysis for acids and bases

- volume-volume stoichiometry (solutions only) and application of volumetric analysis, including the use of indicators, calculations related to the preparation of [standard solutions](#), dilution of solutions, and use of acid-base titrations (excluding back titrations) to determine the concentration of an acid or a base in a water sample

Measuring gases

- CO_2 , CH_4 and H_2O as three of the major gases that contribute to the natural and enhanced greenhouse effects due to their ability to absorb infrared radiation
- the definitions of gas pressure and standard laboratory conditions (SLC) at 25°C and 100 kPa
- calculations using the ideal gas equation ($pV = nRT$), limited to the units kPa, Pa, atm, mL, L, $^\circ\text{C}$, and K (including unit conversions)
- the use of stoichiometry to solve calculations related to chemical reactions involving gases (including moles, mass and volume of gases)
- calculations of the molar volume or molar mass of a gas produced by a chemical reaction

Acid-base (proton transfer) reactions in water:

- the [Brønsted-Lowry](#) theory of acids and bases, including [polyprotic acids](#) and [amphiprotic species](#), and the writing of balanced ionic and full equations, with states, for their reactions in water
- the ionic product of water, the [pH](#) scale and the use of pH in the measurement and calculations of strengths of acids and bases and [dilutions](#) of solutions (calculations involving acidity constants are not required)
- the distinction between [strong and weak acids](#) and strong and weak bases, and between concentrated and dilute acids and bases, including common examples
- the [reactions](#) of acids with metals, carbonates and hydroxides including balanced full and [ionic equations](#), with states

Neutralisation reactions to produce salts:

- reactions of acids with metal carbonates and hydroxides, including balanced full and ionic equations, with states
- types of antacids and their use in the neutralisation of stomach acid
- accuracy and precision in measurement as illustrated by the comparison of natural indicators, commercial indicators, and pH meters to determine the relative strengths of acidic and basic solutions
- applications of acid-base reactions in society: for example, natural acidity of rain due to dissolved CO_2 and the distinction between the natural acidity of rain and acid rain, or the action of CO_2 forming a weak acid in oceans and the consequences for shell growth in marine invertebrates

Water as a unique chemical:

- the existence of water in all three states at Earth's surface, including the distribution and proportion of available drinking water
- the relatively high latent heat of vaporisation of water and its impact on the regulation of the temperature of the oceans and aquatic life
- explanation of the anomalous properties of H_2O (ice and water), with reference to hydrogen bonding:
 - trends in the boiling points of Group 16 hydrides
 - the density of solid ice compared with liquid water at low temperatures
 - specific heat capacity of water including units and symbols

Redox (electron transfer) reactions:

- oxidising and reducing agents, and redox reactions, including writing of balanced half and overall redox equations (including in acidic conditions), with states
- the reactivity series of metals and metal displacement reactions, including balanced redox equations, with states
- applications of redox reactions in society: for example, corrosion or the use of simple primary cells in the production of electrical energy from chemical energy

Analysis for salts:

- sources of salts found in water or soil (which may include minerals, heavy metals, organo-metallic substances) and the use of electrical conductivity to assess the salinity and quality of water or soil samples
- quantitative analysis of salts:
 - molar ratio of water of hydration for an ionic compound
 - the application of mass-mass stoichiometry to determine the mass present of an ionic compound
 - the application of colorimetry and/or UV-visible spectroscopy, including the use of a calibration curve to determine the concentration of ions or complexes in a water or soil sample

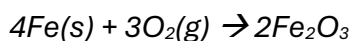
Revision for the 2026 end-of-year examination of (90 minutes)

1. Which volume of gas at 25°C and 1 atm pressure contains 2 moles of gas?
 - a. 49.6 L
 - b. 22.4 L
 - c. 11.2 L
 - d. 0.0821 L
2. What is the molarity of a solution made by dissolving 0.5 mol of solute in 250 mL of solution?
 - a. 0.5 M
 - b. 2.0 M
 - c. 0.125 M
 - d. 0.25 M
3. Which metal will react fastest with dilute hydrochloric acid?
 - a. Copper
 - b. Zinc
 - c. Gold
 - d. Silver
4. A compound X has empirical formula CH_2O and molar mass about 180 g/mol. Its molecular formula is:
 - a. CH_2O
 - b. $\text{C}_3\text{H}_6\text{O}_3$
 - c. $\text{C}_6\text{H}_{12}\text{O}_6$
 - d. $\text{C}_2\text{H}_4\text{O}_2$
5. Which one of the following options is an amphoteric substance?
 - a. H_2SO_4
 - b. NaOH
 - c. HCl
 - d. H_2O
6. In an acid-base titration, between NaOH and an unknown sample of H_2SO_4 , the equivalence point is reached when:
 - a. $\text{pH} = 7$
 - b. 1 mol of acid = 2 mol of base
 - c. the indicator undergoes a colour change
 - d. the acid is in excess

7. The density of ice is less than the density of water due to the:
- weak dispersion forces present in the liquid state.
 - weak dipole-dipole bonding present in the liquid state.
 - strong dispersion forces holding water molecules tightly together in the liquid state.
 - strong hydrogen bonding holding the water molecules into a rigid 3-dimensional lattice structure in ice.

Use the information below to answer questions 8 and 9

Iron reacts with oxygen to form an ionic compound according to the equation below.



8. What volume of oxygen gas, at STC, is needed to fully react with 5.58 g of iron.

- $58.0 \times \frac{3}{4} \times 24.8 \text{ L}$
- $\frac{5.58}{58} \times 1000 \times 24.8 \text{ mL}$
- $\frac{58}{5.58} \times \frac{3}{4} \times 24.8 \text{ L}$
- $\frac{5.58}{58} \times \frac{3}{4} \times 24.8 \text{ L}$

9. Which of the following is amphoteric?

- HCl
- H₂O
- NaOH
- CO₂

10. Phenolphthalein is used as an indicator in titration experiments. When an unknown solution of NaOH is titrated against a standardised HCl solution the phenolphthalein changes colour from :

- pink to clear
- clear to pink
- clear to green
- green to clear

11. Which element has the highest electronegativity?

- Sodium
- Oxygen
- Chlorine
- Fluorine

12. Which factor increases the rate of a reaction?
- Lower temperature
 - Lower concentration
 - Adding a catalyst
 - Reducing surface area
13. Consider the two half cells Zn^{2+}/Zn and Mn^{2+}/Mn . Which comment is true when these two cells are connected with a salt bridge and an external circuit.
- Electrons flow through the salt bridge to the Zn electrode
 - Cations flow to the Zn electrode
 - A voltage of 0.42 V is produced
 - No spontaneous reaction will occur.
14. Electrolysis of water takes place according to the equation below. What is the mole ratio of H_2 to O_2 needed in water formation?
- $$2\text{H}_2\text{O}_{(l)} \rightarrow 2\text{H}_{2(l)} + \text{O}_{2(g)}$$
- 1:1
 - 2:1
 - 2:3
 - 3:2
15. The pH scale measures:
- concentration of OH^- ions
 - concentration of H_3O^+ ions
 - concentration of Na^+ ions at pH of 7
 - temperature of water at a pH of 7
16. Which solution has the highest pH?
- 0.01 M NaOH
 - 0.1 M HCl
 - 0.001 M HNO_3
 - 0.05 M CH_3COOH
17. 36.0 grams of an unknown gas is placed in 20.0 L sealed vessel at a pressure of 303 kPa and temperature of 333 °C. The gas is most likely:
- O_2
 - H_2
 - CO_2
 - NO

18. A 20.0 mL aliquot of a 0.141 M Na_2CO_3 (106.0 g/mol) is added to a 250 mL volumetric flask and made to the mark with distilled water.
What is the concentration of Na_2CO_3 in the flask?
- a. 1.13 % (m/v)
 - b. 1.13 ppm
 - c. 0.00113 M
 - d. 1.13×10^{-2} M
19. The total amount, in mol, of ions present in 45.0 g of NaCl (M = 58.44 g/mol) is:
- a. 0.77 mol
 - b. 1.54 mol
 - c. 2.69 mol
 - d. 3.75 mol
20. Which one of the following acids has the highest ion concentration in solution?
- a. 1.00 M HCl
 - b. 1.00 M H_2CO_3
 - c. 0.5 M CH_3COOH
 - d. 1.00 M HF
21. A sealed container has 2 mol of gas at 300 K and 100 kPa. If the volume of the container is doubled at constant temperature, the pressure will:
- a. halve
 - b. double
 - c. stay the same
 - d. reduce to 25% of the original volume
22. A solution of 0.1 M HCl has a pH of:
- a. 1
 - b. 7
 - c. 3
 - d. 0
23. The molar mass of an unknown gas is found by measuring pressure, volume and temperature. The gas is:
- a. Ideal gas
 - b. Real gas
 - c. Heavier than air
 - d. Lighter than air

24. Which ions contribute most to electrical conductivity in a HCl solution?

- a. H_3O^+ and Cl^-
- b. Mg^{2+} and HO^-
- c. H_3O^+ and NO_3^-
- d. Ca^{2+} and HCO_3^-

25. The reducing agent in the reaction $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$ is:

- a. Zn
- b. Cu^{2+}
- c. Zn^{2+}
- d. Cu

26. Which salt is acidic when dissolved in water?

- a. NH_4Cl
- b. NaCl
- c. KNO_3
- d. Na_2CO_3

27. In an acid/base titration, the end point is reached:

- a. when the unknown solution becomes neutral
- b. when the indicator changes colour
- c. when the acid reacts completely
- d. when base reacts completely

28. Which reaction produces a gas?

- a. $\text{Na}_2\text{CO}_3 + \text{HCl} \rightarrow$
- b. $\text{NaOH} + \text{HCl} \rightarrow$
- c. $\text{AgNO}_3 + \text{NaCl} \rightarrow$
- d. $\text{BaCl}_2 + \text{Na}_2\text{SO}_4 \rightarrow$

29. Which one is an example of a redox reaction?

- a. $\text{Fe} + \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$
- b. $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
- c. $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$
- d. Both a and c

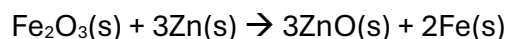
30. Which chemical acts as an oxidizing agent?

- a. Zn
- b. H_2
- c. Cu^{2+}
- d. Fe

31. The pH of a 0.001 M NaOH solution is approximately:
- 3
 - 7
 - 11
 - 13
32. A bottle of wine is labelled 13% (v/v) of ethanol. Given that the density of ethanol is 0.789 g/mL, the concentration can also be expressed as:
- 1.3 ppm
 - 0.13 ppm
 - 13% (m/m)
 - 10.3% (m/v)
33. How many molecules are present in 0.5 mol CO₂?
- 3.01×10^{24}
 - 6.02×10^{23}
 - 1.20×10^{24}
 - 3.01×10^{23}
34. What volume, in litres, does 0.200 grams of H₂ gas occupy at STC?
- 22.4
 - 13.2
 - 1.00
 - 4.96
35. Which salt is insoluble in water?
- NaCl
 - Mg(NO₃)₂
 - KNO₃
 - AgCl
36. In the reaction $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, the oxidizing agent is:
- H₂
 - H₂O
 - O₂
 - None of the above

37. Which is the conjugate base of H_2SO_4 ?
- HSO_4^-
 - SO_4^{2-}
 - H_2SO_4
 - H_3SO_4^+
38. Which statement correctly distinguishes a standard solution from a primary standard?
- A standard solution is a solution of known concentration, whereas a primary standard is a highly pure solid used to prepare standard solutions.
 - A primary standard is always an acid, while a standard solution is always a base.
 - A standard solution is less accurate than a primary standard.
 - A primary standard is a solution, while a standard solution is used to make a primary standard.
39. A fertiliser is labelled as containing 0.25 % (m/m) of calcium (Ca). It can also be labelled as containing what concentration of calcium?
- 10% (m/m)
 - 0.25 ppm
 - 2500 ppm
 - 25 ppm
40. 2.00 mol of liquid fuel was burned to heat 100 grams of water at 25.0°C to 45.0°C . What is the calculated energy content of the liquid fuel?
- 4.180 J/g
 - 4180 kJ/g
 - 4.18 kJ/mol
 - 8.36 kJ/mol
41. A 0.500 g sample of fuel with an energy density of 23.6 kJ/g burns completely to heat 50.0 g of water initially at 25°C . Which statement is most correct, assuming no energy is lost to the environment?
- The water would reach a temperature close to 33°C
 - The water would reach a temperature close to 56°C
 - The water would reach a temperature close to 41°C
 - The water would reach a temperature close to 82°C

42. Iron(III) oxide reacts with zinc metal in the presence of water according to the reaction shown below.

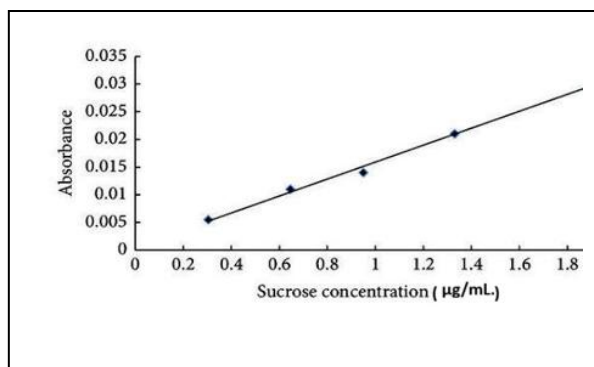


Which one of the following options represents the oxidation reaction?

- a. $\text{Fe}_2\text{O}_3(\text{s}) + 6\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 3\text{H}_2\text{O}(\text{l}) + 2\text{Fe}(\text{s})$
- b. $\text{Fe}_2\text{O}_3(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2\text{O}(\text{l}) + 2\text{Fe}(\text{s})$
- c. $\text{Zn}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^-$
- d. $\text{Zn}(\text{s}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$

The information shown below refers to questions 43, 44 and 45.

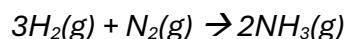
Consider the calibration curve shown below of absorbance, as measured by spectrophotometer and sucrose concentration.



43. An unknown solution has an absorbance of 0.02. The likely sucrose concentration of the unknown solution is:
- a. 0.00014% (m/v)
 - b. 0.14 g/mL
 - c. 0.00014 ppm
 - d. 1.4 g/L
44. How many standard solutions were used to create this curve?
- a. 5
 - b. 6
 - c. 4
 - d. 3
45. Which absorbance reading would give the most inaccurate concentration reading?
- a. 0.01
 - b. 0.02
 - c. 0.03
 - d. 0.015

The following information relates to questions 46, 47 and 48.

Hydrogen and nitrogen gases react to form ammonia (NH₃) at SLC, according to the reaction shown below.



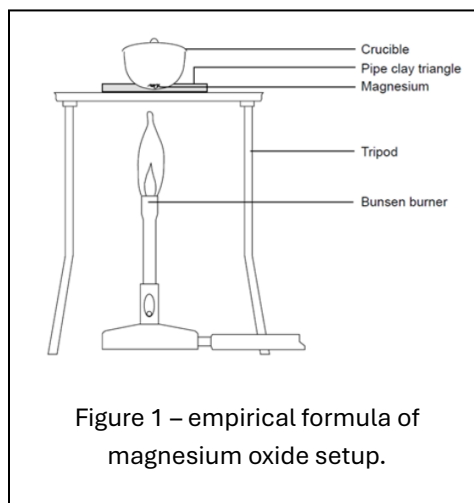
46. What volume of ammonia is produced if 8 mol of hydrogen gas is mixed with 3 mol of nitrogen gas?
- $8 \times \frac{2}{3} \times 24.8 \text{ L}$
 - $3 \times 2 \times 24.8 \text{ L}$
 - $3 \times \frac{2}{3} \times 24.8 \text{ mL}$
 - $8 \times \frac{2}{1} \times 24.8 \text{ mL}$
47. Which statement is true?
- Nitrogen gas is in excess by approximately 3 mol.
 - Nitrogen gas is in excess by approximately 0.3 mol.
 - Hydrogen gas is in excess by approximately 0.3 mol.
 - Hydrogen gas is in excess by approximately 5 mol.
48. In another experiment 3.0 grams of N₂ and 3 grams of H₂ are mixed in a sealed vessel and allowed to react. What mass of ammonia (NH₃, 17.0 g/mol) is formed?
- Approximately 3.0 grams of NH₃ will form where N₂ is the limiting reactant.
 - Approximately 6.0 grams of NH₃ will form as the law of conservation of mass is maintained.
 - Approximately 3.0 grams of NH₃ will form where H₂ is the limiting reactant.
 - Approximately 3.6 grams of NH₃ will form, where N₂ is the limiting reactant.
49. A sample of waste water contains lead metal as well as copper and cobalt. Which of the following solutions can be used to remove the lead (Pb²⁺) metal only?
- Sodium phosphate.
 - Sodium nitrate
 - Potassium sulfate
 - Potassium hydroxide
50. Which of the following best represents the formula for Iron(II) phosphate?
- FePO₄
 - Fe₂(PO₄)₃
 - Fe₃(PO₄)₂
 - Fe₂PO₄

51. What is the primary cause of acid rain?
- Carbon dioxide (CO₂) emissions
 - Nitrogen oxides (NO_x) and sulfur dioxide (SO₂) emissions
 - Methane (CH₄) release
 - Ozone (O₃) depletion
52. Which Green Chemistry principle most directly helps reduce emissions causing acid rain and ocean acidification?
- Design for energy efficiency
 - Use of renewable feedstocks
 - Prevent waste
 - Safer solvents and auxiliaries
53. Ocean acidification mainly impacts marine invertebrates by:
- creating murky waters that light cannot penetrate
 - dissolving plant food sources
 - reducing the amount of oxygen dissolved in ocean waters
 - reducing the amount of CO₃²⁻(aq) available for shell or skeletal formation
54. Which solution will exhibit the highest conductivity?
- 2.0 M Na₂CO₃
 - 0.1 M HCl
 - 2.0 M KCl
 - 1.9 M Na₃PO₄
55. The active ingredient in a popular brand of antacid is NaHCO₃. Which statement best represents the reaction taking place in the stomach to alleviate the symptoms of high stomach acid when a solid tablet is ingested?
- NaHCO₃(l) + HCl(aq) → CO₂(g) + H₂O(l) + NaCl(s)
 - 2NaHCO₃(aq) + H₂SO₄(aq) → 2CO₂(g) + 2H₂O(l) + Na₂SO₄(aq)
 - NaHCO₃(s) + HCl(aq) → H₂(g) + CO₂(g) + NaOCl(aq)
 - NaHCO₃(s) + HCl(aq) → CO₂(g) + H₂O(l) + NaCl(aq).

Section B

Question 1 (9 marks)

A student was tasked with experimentally determining the empirical formula of magnesium oxide. The setup used is shown in fig. 1. The table of results, table 1, shows the results from three different trials.



Trial	Mass of Empty Crucible (g)	Mass of Crucible + Magnesium (g)	Mass of Crucible + Magnesium Oxide (g)	Mass of Magnesium Oxide (g)
1	25.00	25.27	25.45	0.59
2	25.00	25.31	25.69	0.69
3	25.00	25.29	25.35	0.35

Table 1 – experimental results.

a. Using the results from trial 1 calculate the following.

i. The mass of Mg used 1 mark

ii. The mass of oxygen that reacted 1 mark

iii. Calculate the mol of Magnesium in the crucible 1 mark

iv. Calculate the mol of oxygen that reacted 1 mark

v. Calculate the empirical formula of magnesium oxide

1 mark

b. The mass of magnesium oxide formed in trial 3 differs markedly from trials 1 and 2. Give a possible error that may have resulted in the low yield of oxide?

2 marks

c. The error given as the answer to question b. is what type of error. Justify your answer.

2 marks

Question 2 (12 marks)

A laboratory was asked to verify the concentration of ethanoic acid found in a Coles brand double strength white vinegar. Volumetric analysis of the vinegar was undertaken and the following steps taken.

- i. Place 20.00 mL aliquot of the sample vinegar into a 200 mL volumetric flask.
- ii. Add water to the volumetric flask until the liquid level reaches the calibration mark.
- iii. Take a 20.00 mL aliquot from the volumetric flask and place it in a 100 mL conical flask.
- iv. Add 2 drops of indicator.
- v. Titrate against a standard 0.112 M Na_2CO_3 solution until the end point is reached.
- vi. Repeat steps iii – v until concordant results are achieved.



Figure 2 – commercial brand of white vinegar.

The reaction between the vinegar and the sodium hydrogen carbonate (NaHCO_3) is given below.



- a. Assuming the average titre was found to be 23.50 mL, calculate the amount, in mol, of NaHCO_3 in an average titre. 2 marks

- b. Calculate the amount, in mol, of vinegar present in the 20.00 mL sample placed in the conical flask. 1 mark

c. Find the concentration, in mol/L, of ethanoic acid in the volumetric flask.

2 marks

d. Find the concentration of ethanoic acid in the original sample.

2 marks

e. Assuming phenolphthalein was used as the indicator what colour change would indicate the end point?

_____ 1 mark

f. Why is the NaHCO_3 solution referred to as a standard solution?

_____ 1 mark

g. What is the solid NaHCO_3 , used to make the standard solution, referred to.

_____ 1 mark

h. Name two properties that the NaHCO_3 used to make the standard solution should have.

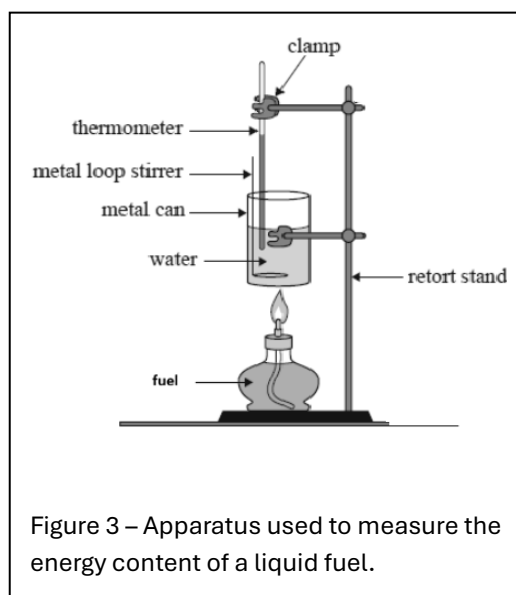
Question 3 (12 marks)

An unknown fuel was analysed for its energy content using the apparatus shown in fig. 3.

A mass of 200 grams of water was placed in a metal can and heated using a spirit burner filled with the unknown fuel.

The spirit burner and fuel was weighed before and after burning and found to have lost 3.15 grams of mass.

The temperature of the water increased by 23.4 °C. (ΔT).



a. Find the energy, joules (J), absorbed by the water.

2 marks

b. Find the mass of fuel that burned.

1 mark

c. Find the energy density of the fuel in kJ/kg

3 marks

- d. The thermometer was found to be poorly calibrated and always gave a temperature reading $2.00\text{ }^{\circ}\text{C}$ above the actual temperature of the water. What impact would this have on the answer given to question c. above? Justify your answer.

_____ 2 marks

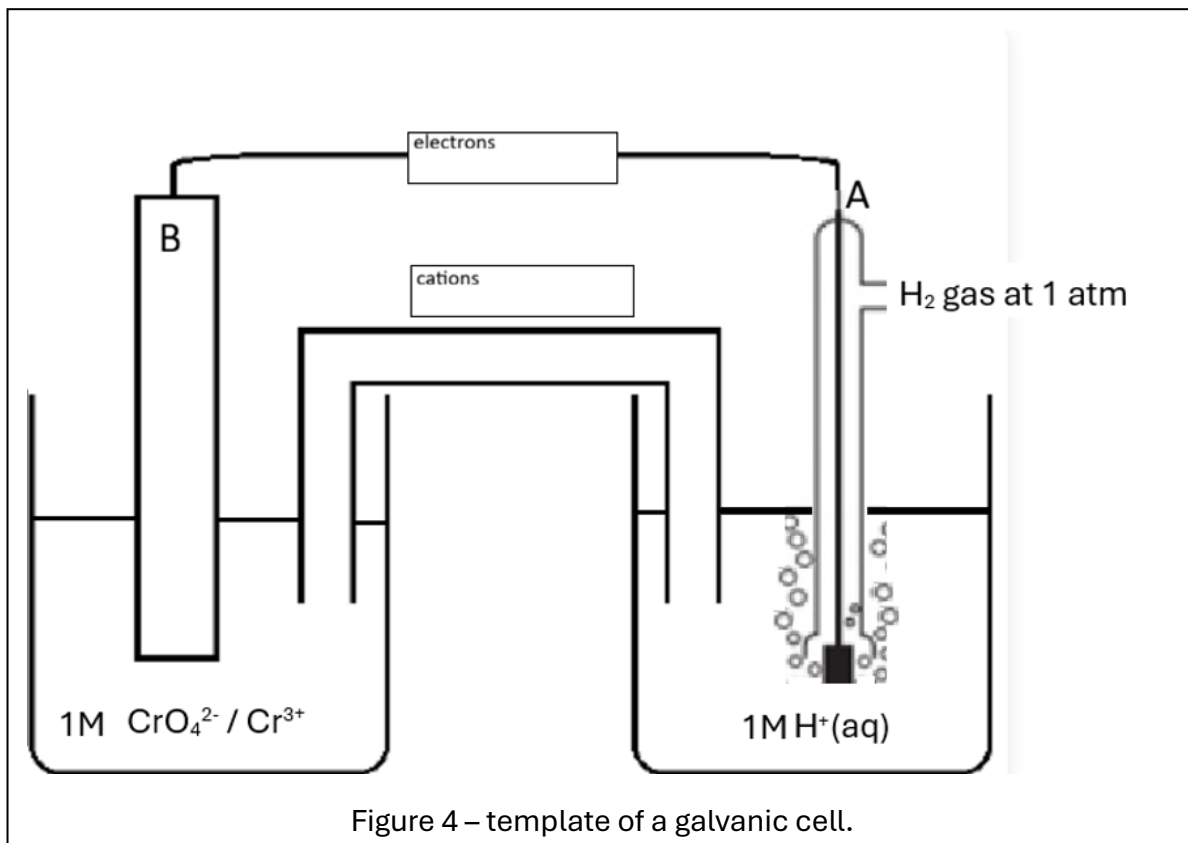
- e. Whilst conducting the investigation the stirrer was not used throughout the course of heating the water and the thermometer was placed so that it touched the bottom of the metal can.
- i. What impact would this have the final answer given in question c above? Justify your answer.

_____ 2 marks

- ii. Comment on how this impacts the validity of the results obtained. Justify your answer.

Question 4 (10 marks)

Consider the galvanic cell shown in fig 4 below.



- a. Label the following in the box provided in the image. 2 marks
- Direction of electron flow.
 - Direction of cation flow.

- b. What material are the following electrodes made of?

Electrode A _____ 1 mark

Electrode B _____ 1 mark

- c. Given that the $\text{CrO}_4^{2-} / \text{Cr}^{3+}$ half-cell has a standard electrode potential of +1.33 V, calculate the theoretical cell EMF in volts. 2 marks

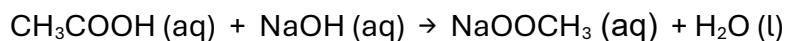
- d. Write the balanced reduction half equation

2 marks

- e. Write the balanced overall redox equation for the cell.

Question 5 (12 marks)

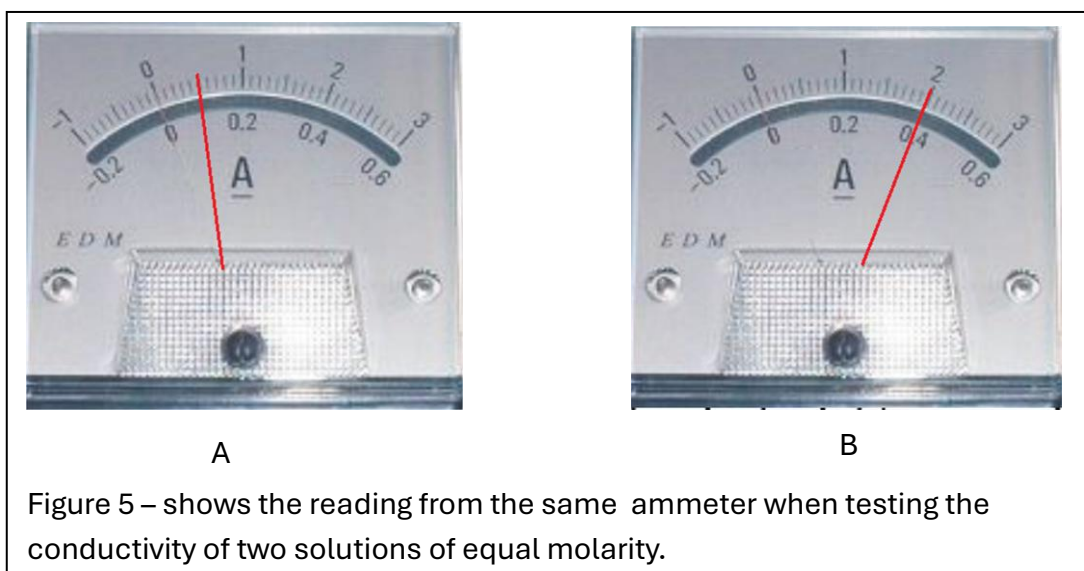
Acetic acid (CH_3COOH) reacts with sodium hydroxide (NaOH) according to the reaction below.



- a. Select the type of acid represented by acetic acid by circling the correct response/s from the list below. 1 mark

Strong weak triprotic amphiprotic monoprotic

- b. Two solutions, 1 M CH_3COOH and 1M HNO_3 , were tested for electrical conductivity using the same ammeter. The results are shown in fig. 5.



Which reading, A or B, belongs to the HNO_3 solution?

Justify your answer

c. Phosphoric acid (H_3PO_4) reacts with sodium oxide (Na_2O).

- i. Assuming the acid fully ionises, write the overall balanced chemical equation, states included.

3 marks

- ii. Write the net ionic equation for this reaction.

2 marks

d. Consider a 0.0523 M HCl solution at 25°C .

- i. Calculate the pH of the solution to the right number of significant figures
2 marks

- ii. Calculate the $[\text{OH}^-]$ 2 marks