

**Section 1: Multiple-choice****25% (25 Marks)**

This section has **25** questions. Answer **all** questions on the Multiple-choice Answer Sheet provided. Use only blue or black pen to shade the boxes. If you make a mistake, place a cross through that square. Do not erase or use correction fluid. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is given for any question.

Suggested working time for this section is 50 minutes.

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1. The set below that contains an ionic substance, a molecule and a covalent network lattice (not necessarily in that order) is:

- A.  $\text{SiO}_2$ ;  $\text{CO}_2$ ;  $\text{Na}_2\text{O}$
- B.  $\text{HCl}$ ;  $\text{NaCl}$ ;  $\text{Cl}_2\text{O}_7$
- C.  $\text{Al}_2\text{O}_3$ ;  $\text{H}_2\text{O}$ ;  $\text{HF}$
- D. graphite;  $\text{CO}_2$ ;  $\text{CH}_4$

2. Which two of the following compounds may be used as primary standards in quantitative analysis?

- (1)  $\text{Na}_2\text{CO}_3(\text{s})$                       (2)  $\text{KMnO}_4(\text{s})$                       (3)  $\text{H}_2\text{O}_2(\text{aq})$   
(4)  $\text{NaOH}(\text{s})$                       (5)  $\text{HOOC}\text{COOH}$

- A. (1) and (2)
- B. (1) and (5)
- C. (2) and (3)
- D. (4) and (5)

3. In which one of the following would the position of the equilibrium **NOT** be affected by a volume change at constant temperature?

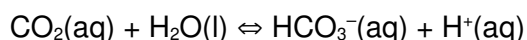
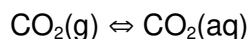
- A.  $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}_2(\text{g})$
- B.  $\text{C}_2\text{H}_6(\text{g}) \rightleftharpoons \text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g})$
- C.  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
- D.  $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{CO}_2(\text{g})$

4. In which of the following reactions is water behaving as an acid?

- A.  $\text{H}_2\text{O}(\text{g}) + \text{Mg}(\text{s}) \rightarrow \text{MgO}(\text{s}) + \text{H}_2(\text{g})$
- B.  $\text{H}_2\text{O}(\text{l}) + \text{CH}_3\text{NH}_2(\text{aq}) \rightarrow \text{CH}_3\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$
- C.  $\text{H}_2\text{O}(\text{l}) + \text{HCO}_3^-(\text{aq}) \rightarrow \text{CO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$
- D.  $\text{H}_2\text{O}(\text{l}) + \text{NH}_4^+(\text{aq}) \rightarrow \text{NH}_4\text{OH}(\text{aq}) + \text{H}^+(\text{aq})$

5. The oxidation numbers of nitrogen in  $\text{HNO}_3$ ,  $\text{NO}$  and  $\text{NH}_2\text{OH}$  are
- 1, +2 and +1 respectively
  - 5, +2 and -1 respectively.
  - +5, +2 and -1 respectively.
  - +5, +4 and +1 respectively.
6. Which of the following combinations of reactants can be used to make a condensation polymer?
- $\text{CH}_3(\text{CH}_2)_4\text{COOH}$  and  $\text{HOCH}_2(\text{CH}_2)_4\text{CH}_3$
  - $\text{HOCH}_2(\text{CH}_2)_4\text{CH}_2\text{OH}$  and  $\text{HOOC}(\text{CH}_2)_4\text{COOH}$
  - $\text{CH}_3(\text{CH}_2)_4\text{CH}_2\text{OH}$  and  $\text{HOOC}(\text{CH}_2)_4\text{COOH}$
  - $\text{CH}_2=\text{CH}_2$  and  $\text{CH}_2=\text{CHCl}$
7. Which one of these metals would not be suitable to use as a sacrificial anode to prevent the corrosion of iron?
- Magnesium.
  - Zinc.
  - Chromium.
  - Copper.
8. Which one of the following correctly arranges 1.0 mol  $\text{L}^{-1}$  solutions of the substances in the order of increasing pH?
- $\text{HCl}$     $\text{H}_2\text{SO}_4$     $\text{CH}_3\text{COONa}$     $\text{CH}_3\text{COOH}$     $\text{NH}_4\text{CH}_3\text{COO}$
  - $\text{H}_2\text{SO}_4$     $\text{HCl}$     $\text{CH}_3\text{COOH}$     $\text{NH}_4\text{CH}_3\text{COO}$     $\text{CH}_3\text{COONa}$
  - $\text{H}_2\text{SO}_4$     $\text{HCl}$     $\text{CH}_3\text{COOH}$     $\text{CH}_3\text{COONa}$     $\text{NH}_4\text{CH}_3\text{COO}$
  - $\text{HCl}$     $\text{H}_2\text{SO}_4$     $\text{NH}_4\text{CH}_3\text{COO}$     $\text{CH}_3\text{COOH}$     $\text{CH}_3\text{COONa}$
9. Which one of the following compounds will react (in the presence of a concentrated sulphuric acid catalyst) with its own oxidation product to give a sweet-smelling liquid?
- propanal
  - 2-propanol
  - 1-propanol
  - propanoic acid

10. The solubility of  $\text{CO}_2(\text{g})$  in water can be represented by the following equilibria:



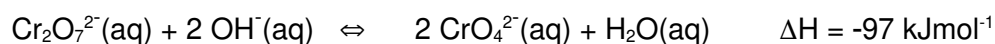
Which of the following would increase the solubility of  $\text{CO}_2$  gas in water?

- A. adding  $\text{HCl}(\text{aq})$
  - B. adding solid  $\text{NaOH}$
  - C. adding solid  $\text{KHCO}_3$
  - D. increasing the volume of the container
11. Which one of the following best describes the polarity of bonds and molecular polarity in a  $\text{CCl}_4$  molecule?
- A. polar covalent bonds, non polar molecule
  - B. polar covalent bonds, polar molecule
  - C. non polar covalent bonds, non polar molecule
  - D. non polar covalent bonds, polar molecule
12. A student completed an experiment where he titrated sulphamic acid against sodium carbonate to determine the amount of water present in the crystalline carbonate. The burette used was cleaned by first rinsing with sulphamic acid and then finally rinsing with distilled water. This final rinse with distilled water will:
- A. give greatest accuracy for the burette.
  - B. decrease the amount titrated and give a higher value for the amount of water present in the carbonate.
  - C. increase the amount titrated and give a lower value for the amount of water present in the carbonate.
  - D. increase the amount titrated and give a higher value for the amount of water present in the carbonate.
13. How many isomeric alkenes are there of  $\text{C}_4\text{H}_8$ ?
- A. 3
  - B. 4
  - C. 5
  - D. 6

14. The valence structure [dot diagram] of the carbon disulfide molecule has:
- A. 4 bonding electrons and 4 pairs of non-bonding electrons [lone pairs]
  - B. 4 bonding pairs of electrons and 4 pairs of non-bonding electrons
  - C. 4 bonding pairs of electrons and 4 nonbonding electrons
  - D. 4 bonding electrons and 4 nonbonding electrons
15. The most abundant product from the reaction of 2 mole of chlorine with 1 mole of methane in ultraviolet light is likely to be
- A.  $\text{CH}_3\text{Cl}$
  - B.  $\text{CH}_2\text{Cl}_2$
  - C.  $\text{CCl}_4$
  - D.  $\text{HCl}$

**The following information refers to questions 16 and 17.**

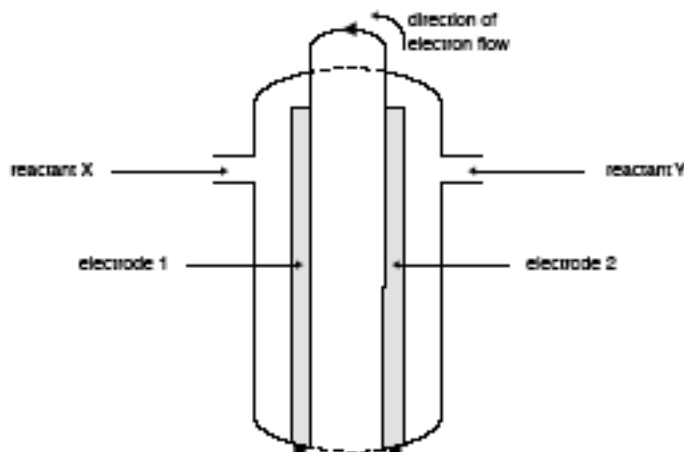
In aqueous solution an equilibrium exists between dichromate and chromate ions as represented in the following equation:



16. If concentrated sulfuric acid is added to an equilibrium system of chromate and dichromate ions then:
- A. the equilibrium position shifts to the left.
  - B. the equilibrium position shifts to the right.
  - C. there is no change in the colour.
  - D. green chromium (III) sulfate forms.
17. If an equilibrium system of dichromate and chromate ions is heated:
- A. the equilibrium position shifts to the right.
  - B. the colour becomes more yellow.
  - C. there is no change in colour.
  - D. the equilibrium position shifts to the left.

**Use the following information to answer Questions 18 and 19.**

Fuel cells are electrochemical cells that convert chemical energy into electrical energy. The diagram below shows an **alkaline hydrogen-oxygen** fuel cell.



18. The alternative that gives the correct polarity of electrodes 1 and 2, given the direction of electron flow shown, and the name of reactants X and Y, is

	Electrode 1	Electrode 2	Reactant X	Reactant Y
A.	positive	negative	O <sub>2</sub> (g)	H <sub>2</sub> (g)
B.	positive	negative	H <sub>2</sub> (g)	O <sub>2</sub> (g)
C.	negative	positive	O <sub>2</sub> (g)	H <sub>2</sub> (g)
D.	negative	positive	H <sub>2</sub> (g)	O <sub>2</sub> (g)

19. The reactions at the anode and cathode are respectively:

	Anode reaction	Cathode reaction
A.	$\text{H}_2(\text{g}) \rightleftharpoons 2\text{H}^+(\text{aq}) + 2\text{e}^-$	$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}(\text{l})$
B.	$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}(\text{l})$	$\text{H}_2(\text{g}) \rightleftharpoons 2\text{H}^+(\text{aq}) + 2\text{e}^-$
C.	$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightleftharpoons 4\text{OH}^-(\text{aq})$	$\text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightleftharpoons 2\text{H}_2\text{O}(\text{l}) + 2\text{e}^-$
D.	$\text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightleftharpoons 2\text{H}_2\text{O}(\text{l}) + 2\text{e}^-$	$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightleftharpoons 4\text{OH}^-(\text{aq})$

20. The first eight ionisation energies of an element are given below:

	Energy / MJ mol <sup>-1</sup>
1st	1.68
2nd	3.36
3rd	6.07
4th	8.41
5th	11.0
6th	15.1
7th	17.9
8th	91.6

Which one of the following statements is correct?

- A. The element has metallic properties.
  - B. The element is in Group 17 of the periodic table.
  - C. The element has 4 outer shell electrons.
  - D. Atoms of the element would tend to form doubly charged ions
21. The magnitude of the equilibrium constant,  $K$ , for the reaction below is  $1.3 \times 10^{-3}$  at 25°C.
- $$\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{O}(\text{g})$$

A sealed flask containing water at 25°C has a water vapour concentration of  $6.0 \times 10^{-5} \text{ mol L}^{-1}$ . Which of the following will occur?

- A. The mass of liquid present will increase.
- B. The mass of liquid present will remain unchanged.
- C. The rate of the forward reaction will be greater than the rate of the back reaction until equilibrium is re-established.
- D. The forward and back reaction will remain at the same rate.

22. 25.0 mL of 0.450 mol L<sup>-1</sup> nitric acid is added to 80.0 mL of 0.0300 mol L<sup>-1</sup> barium hydroxide. What is the final hydrogen ion concentration?
- A. 0.00645
  - B. 0.0614
  - C. 0.00885
  - D. 0.0843
23. If equal masses of each of the following are burned in excess oxygen, which will give the greatest mass of CO<sub>2</sub>?
- A. C<sub>2</sub>H<sub>2</sub>
  - B. CH<sub>3</sub>OH
  - C. CH<sub>4</sub>
  - D. (CH<sub>3</sub>)<sub>2</sub>O
24. Which compound has the highest vapour pressure at 25°C?
- A. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH
  - B. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CHO
  - C. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>
  - D. (CH<sub>3</sub>)<sub>3</sub>COH
25. An electrochemical cell was constructed using a silver rod in a solution of silver nitrate, and a cadmium rod in a solution of cadmium nitrate. Which of the following statements is true?
- A. The silver rod is the anode, and the positive ions flow from silver to cadmium in the salt bridge.
  - B. The silver rod is the anode, and the positive ions flow from cadmium to silver in the salt bridge.
  - C. The silver rod is the cathode, and the positive ions flow from silver to cadmium in the salt bridge.
  - D. The silver rod is the cathode, and the positive ions flow from cadmium to silver in the salt bridge

**Section2: Short Answer****35% (70 marks)**

This section has **12** questions. Answer all questions. Write your answers in the space provided. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page
- Continuing an answer. If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued. i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 60 minutes.

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**Question 26****(6 marks)**

Write the equation for the reaction that occurs in each of the following procedures. If no reaction occurs, write 'no reaction'. For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be ions [for example  $\text{Ag}^+(\text{aq})$ ], molecules [for example  $\text{NH}_3(\text{g})$ ,  $\text{NH}_3(\text{aq})$ ,  $\text{CH}_3\text{COOH}(\text{l})$ ] or solids [for example  $\text{BaSO}_4(\text{s})$ ,  $\text{Cu}(\text{s})$ ,  $\text{Na}_2\text{CO}_3(\text{s})$ ].

- (a) Pieces of chromium are warmed with concentrated nitric acid.

Equation \_\_\_\_\_

Observation \_\_\_\_\_

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(3 marks)

- (b) Bromine solution is added to cis 2-butene.

Equation \_\_\_\_\_

Observation \_\_\_\_\_

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(3 marks)



**Question 27****(4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe what you would observe, including any:

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(a) Copper carbonate dissolves in dilute sulfuric acid.

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(2 marks)

(b) Excess lead (II) nitrate solution is mixed with cobalt (II) iodide solution.

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(2 marks)

**Question 28****(4 marks)**

The  $\text{N}_2\text{O}$  molecule is both linear and polar. On the basis of this experimental information, determine whether the arrangement NNO or NON is correct. Draw at least one electron dot diagram for each of these forms to illustrate and help explain your answer.

NNO	NON

(2 marks)

Explanation \_\_\_\_\_

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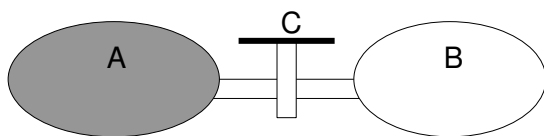
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(2 marks)

**Question 29****(12 marks)**

Vessel A contains an equilibrium mixture of  $\text{CO}$ ,  $\text{Cl}_2$  and  $\text{COCl}_2$  at  $28^\circ\text{C}$ .  
Vessel B is empty; A and B are connected by a tube with a stopcock C.



The equilibrium reaction is

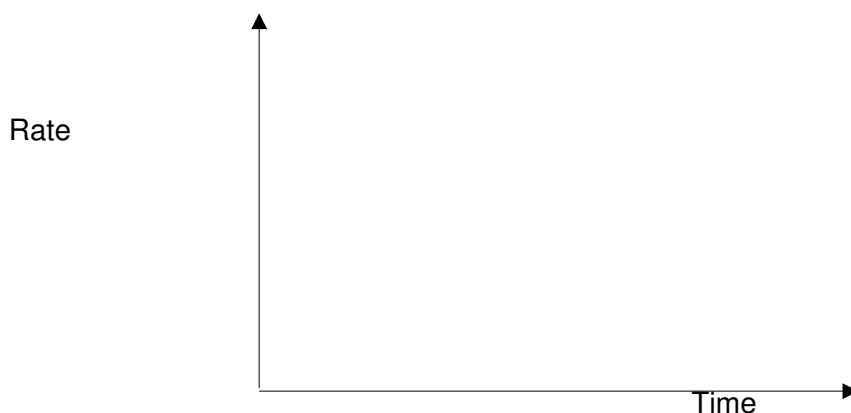


Using the words **increases**, **decreases**, or **no change** determine what happens to the value of  $K$  [equilibrium constant], the value of the  $[\text{Cl}_2]$  and the mass of  $\text{Cl}_2$  when the following two changes (a,b) are made to the initial equilibrium.

Change made	K value	$[\text{Cl}_2]$	Mass of $\text{Cl}_2$
(a) stopcock C is opened at $28^\circ\text{C}$ ; A and B are now connected.			
(b) container A has been immersed in a water bath at $67^\circ\text{C}$ [at constant pressure]			

(6 marks)

- (c) (i) Sketch a graph of what happens to the rate of the **forward** reaction for the **change (a) above**, from when the reaction was initially at equilibrium until equilibrium is re-established after the change is made.



(3 marks)

- (ii) Explain why the rate changes in the way shown in your sketch.

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(3 marks)

**Question 30****(6 marks)**

When an acidified solution of potassium permanganate ( $\text{KMnO}_4$ ) is added to a solution of potassium chlorate ( $\text{KClO}_3$ ), the main products formed are manganese (IV) dioxide ( $\text{MnO}_2$ ) and potassium perchlorate ( $\text{KClO}_4$ ).

Write a balanced equation for this reaction by first balancing the half equations for both the oxidation and reduction processes.

oxidation process

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(2 marks)

reduction process

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(2 marks)

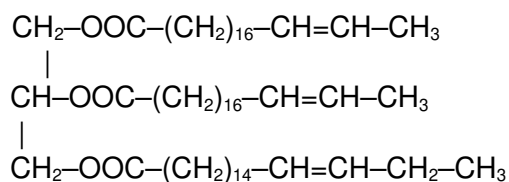
Full balanced equation

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(2 marks)

**Question 31****(3 marks)**

The following triglyceride was boiled (hydrolysed) with sodium hydroxide solution to produce soap. Draw the **structures** of three likely products formed. The triglyceride is :



Product 1	Product 2	Product 3

**Question 32****(4 marks)**

A student titrates a solution of oxalic acid against 20.0 mL of a standardised 0.052 mol L<sup>-1</sup> solution of sodium carbonate in a conical flask using a suitable indicator.

How would the following experimental errors affect the value of the concentration of the oxalic acid calculated from the titration compared to its actual concentration? **(use higher, lower or no change)**

experimental error	Effect on calculated concentration of oxalic acid
(a) He washed the pipette with water	
(b) He washed the burette with water	
(c) He washed the conical flask with sodium carbonate solution	
(d) He added too much water to the conical flask	

**Question 33****(4 marks)**

In column one you are given a clue to an unknown chemical, write the formula, structural where appropriate, for this unknown in column two.

Clue	Formula of unknown chemical
(a) It is the conjugate acid of $\text{CH}_3\text{COOH}$	
(b) It is a saturated isomer of $\text{C}_4\text{H}_8$	
(c) It is the alcohol used to produce 1-propylbutanoate	
(d) It is an amine with seven H atoms	

Question 34

(6 marks)

Give the name and structural formula of the **main organic product(s)** for the following reactions:

Reaction	Structural Formula of the <b>main organic product(s)</b>	Name of the <b>main organic product(s)</b>
(a) excess acidified potassium permanganate is added to ethanal	(1 mark)	(1 mark)
(b) 2-propanol is warmed with methanoic acid in the presence of conc. sulfuric acid	(1 mark)	(1 mark)
(c) cis -2-butene forms an addition polymer. Draw a 3 monomer polymer.	(2 marks)	<b>LEAVE THIS SPACE BLANK</b>

**Question 35**

**(8 marks)**

Give the compound with the lowest melting point of the following trios of solids;  
give an explanation for your choice.

(a)  $\text{P}_4\text{O}_{10}$ ,  $\text{SiO}_2$ ,  $\text{SO}_2$       Compound with highest MP is \_\_\_\_\_  
(1 mark)

Explanation \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
(3 marks)

(b)  $\text{PH}_3$ ,  $\text{NH}_3$ ,  $\text{AsH}_3$       Compound with lowest MP is \_\_\_\_\_  
(1 mark)

Explanation \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
(3 marks)

**Question 36**

**(6 marks)**

An operational electrochemical cell consists of the following half cells:



- (a). Write equations for reactions occurring at the anode and cathode.

Cathode \_\_\_\_\_

Anode \_\_\_\_\_

(2 marks)

- (b). If the anode weighs 10.4 g before the cell is operational and the cathode gained 0.340g after 10 minutes. What is the mass of the anode after 10 minutes?

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(4 marks)

**Question 37**

**(7 marks)**

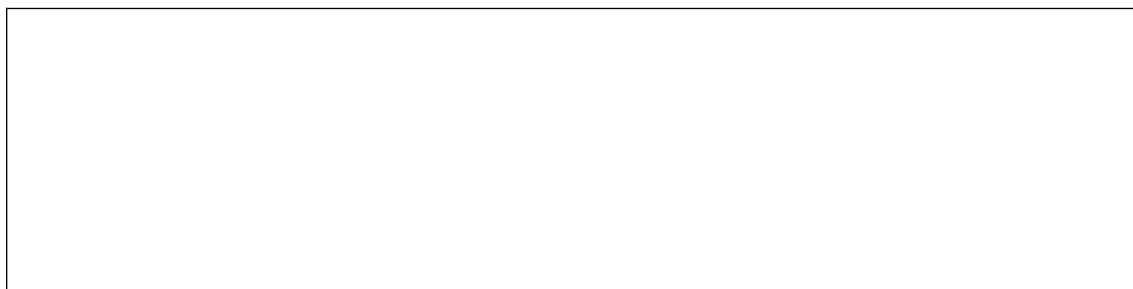
Glycine  $(\text{NH}_2)\text{CH}_2\text{COOH}$  is an amino acid.



- (a) Name the two functional groups that make up this amino acid.

\_\_\_\_\_ and \_\_\_\_\_ (2 marks)

- (b) Draw a three monomer polymer formed by using glycine as the monomer.



(2 marks)

- (c) What would be the mass of a piece of polymer that has been made from **50** glycine molecules?

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(3 marks)

**Section 3: Extended answer**

**40% (80 Marks)**

This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the spaces provided. Spare pages are included at the end of the booklet. They can be used for planning your responses and/ or as additional space if required to continue an answer.

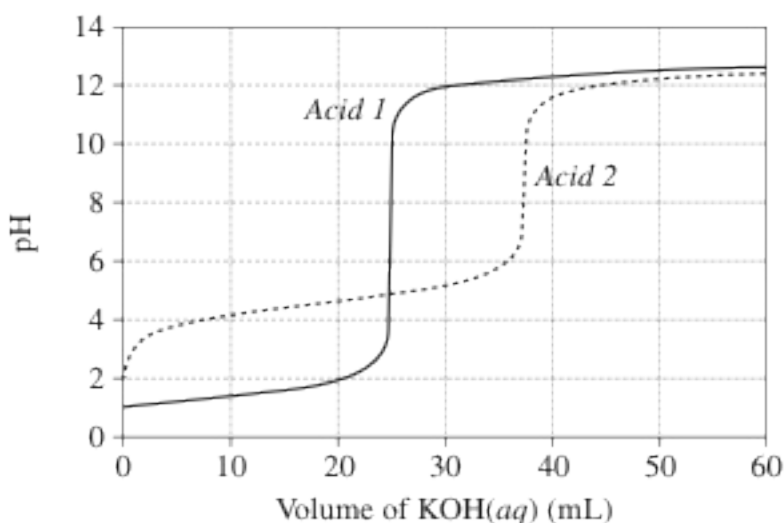
- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 70 minutes.

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**Question 38****(19 marks)**

The graph shows changes in pH for the titrations of equal volumes of solutions of two monoprotic acids, *Acid 1* and *Acid 2*.



- (a) Explain the differences between *Acid 1* and *Acid 2* in terms of their relative strengths and concentrations.

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(4 marks)

- (b) Is the salt produced by the reaction of an acid of the same type as *Acid 2* with  $\text{KOH(aq)}$

acidic, basic or neutral? Explain your choice using relevant chemical equations.

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(3 marks)

- (c) Use the graph to determine the concentration of hydrogen ions when 20 mL of KOH(aq) has been added to *Acid 1*.

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(2 marks)

- (d) Why would phenolphthalein be a suitable indicator for both titrations?

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(1 mark)

- (e) *Acid 1* would be the best acid to use in an investigation to determine the % of ammonia in household cleaner. Explain why.

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(2 marks)

- (f) *Acid 2* is the only acid of the two that could be used to make a buffer solution. Explain why.

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(2 marks)

Consider the following buffer solutions **A** to **C**

- A** 1.0 L of solution containing 1.0 mol L<sup>-1</sup> CH<sub>3</sub>COOH and 1.0 mol L<sup>-1</sup> NaCH<sub>3</sub>COO  
**B** 1.0 L of solution containing 0.1 mol L<sup>-1</sup> CH<sub>3</sub>COOH and 0.1 mol L<sup>-1</sup> NaCH<sub>3</sub>COO  
**C** 1.0 L of solution containing 0.1 mol L<sup>-1</sup> NH<sub>3</sub> and 0.1 mol L<sup>-1</sup> NH<sub>4</sub>Cl

(g) Write the formula of the weak acid and its conjugate base for buffers A and C.

Buffer A    *Weak Acid:* \_\_\_\_\_ *Conjugate base:* \_\_\_\_\_

Buffer C    *Weak Acid:* \_\_\_\_\_ *Conjugate base:* \_\_\_\_\_

(2 marks)

(h) Write an equation to show what happens when a small amount of the strong acid HCl is added to buffer A.

(1 mark)

(i) Use buffers A and B to illustrate the meaning of buffer capacity.

(2 marks)

**Question 39**

**(16 marks)**

An unknown organic compound, A, consisting of only C, H and O was analysed to determine its structure. During analysis compound A was easily oxidised by a potassium permanganate solution to form another compound, B, which reacted with  $\text{Na}_2\text{CO}_3(\text{s})$  to produce a colourless gas.

3.53 g of compound B was completely burnt in excess oxygen to produce carbon dioxide and water which were then completely absorbed into a solution of sodium hydroxide. The mass of the sodium hydroxide solution increased by 7.278 g. In this process the carbon dioxide is completely converted to sodium carbonate. Adding calcium nitrate to this solution results in a precipitate of calcium carbonate. The mass of calcium carbonate when washed and dried was 11.74 g.

- (a) Write a balanced ionic equation for the reaction of carbon dioxide with sodium hydroxide solution.

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(1 mark)

- (b) Write a balanced ionic equation for the reaction between the sodium carbonate and calcium nitrate solutions.

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(1 mark)

- (c) Calculate the mass of carbon dioxide produced during the combustion of compound B.

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(3 marks)

- (d) Calculate the mass of water produced during the combustion of compound B.

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(1 mark)

- (e) Determine the empirical formula of compound B

[illegible]

(5 marks)

Another 7.320 g of compound B was vapourised in 2.00L container and produced a pressure of 200 kPa at 120°C.

- (f) Determine the molecular formula of compound B.

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(3 marks)

- (g) Draw the structural formulae of A and B in the boxes below.

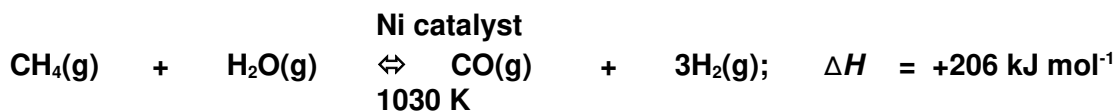
<b>Compound A</b>	<b>Compound B</b>
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(2 marks)

### Question 40

**(13 marks)**

Hydrogen, which is used for the synthesis of ammonia, is sometimes made from the reaction:



In a research laboratory, at  $t = 0$  minutes, 3 moles of methane and water are added to a 1000 mL reaction vessel and equilibrium is established at 2 minutes.

- (a) At time = 3 minutes the concentration of  $\text{CO}(\text{g})$  at 1030 K is doubled by the addition of  $\text{CO}(\text{g})$ . As a result, the temperature in the reaction vessel should

**rise      fall      remain constant**

Circle the correct response **and** explain your answer in the space below.

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(3 marks)

- (b) The mixture is allowed to re-establish equilibrium and then at time = 6 minutes the temperature of the reaction vessel is halved. As a result the yield of hydrogen would

**increase   decrease   remain constant**

Circle the correct response **and** explain your answer in the space below.

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(3 marks)

- (c) The mixture is allowed to re-establish equilibrium and then at  $t = 9$  minutes the total pressure on the reacting system is increased by adding argon (an inert gas) to the reaction

vessel without changing its volume. As a result the yield of hydrogen would

**increase   decrease   remain constant**

Circle the correct response **and** explain your answer in the space below.

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(2 marks)

- (d) On the set of axes below sketch a graph of the concentration of **methane and hydrogen only**, from  $t = 0$  minutes to  $t = 12$  minutes.



Concentration  
(mole L<sup>-1</sup>)



Time  
(4 marks)

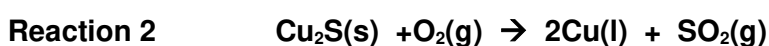
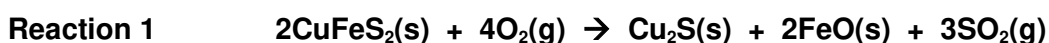
- (e) Equal numbers of mole of methane and water are added to an empty reaction vessel at 1030K in the presence of the nickel catalyst. The system reaches equilibrium. At equilibrium, the concentrations of methane and water are each 0.012 M and the concentration of carbon monoxide is 0.0083 M. What is the concentration of hydrogen?

(1 mark)

**Question 41**

**(15 marks)**

Copper is an extremely useful metal due to its excellent conductivity properties and low reactivity air and water. Most of Australia's copper deposits are in the form of the mineral chalcopyrite ( $\text{CuFeS}_2$ ). Copper is extracted from this ore by roasting the powdered mineral in air. The chemical reactions for the roasting process are shown below.



A particular **ore** body contains 13.6% chalcopyrite by mass. In order to extract the copper it is first crushed and the mineral component, chalcopyrite, concentrated in a process called 'froth floatation'. The **concentrate** is then roasted according to the chemical reactions above.

- (a) What mass of copper can be obtained from 1 tonne ( $10^6$  g) of the **concentrate** if it contains 95.7% chalcopyrite by mass?

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(4 marks)

The by product of the copper extraction ( $\text{SO}_2$ ) is a dangerous pollutant and combines with environmental oxygen and water in similar chemical processes to those used in the Contact Process to produce sulphuric acid.

- (b) Write balanced chemical equations for the reactions of sulphur dioxide with oxygen and subsequently the reaction of the product with water.

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(2 marks)

- (c) Determine the volume of sulphur dioxide produced during **reactions 1 and 2** that would result from the treatment of **one tonne of chalcopyrite ore**. The gas is released at atmospheric conditions of 101kPa and 27°C and the process has a 100% yield.

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(6 marks)

- (d) Determine the mass of sulphuric acid produced **per tonne of chalcopyrite ore** if the reaction of sulphur dioxide with oxygen is 93% efficient. Assume the reaction of the product with water gives a 100% yield.

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(3 marks)

**Question 42****(9 marks)**

On the label of a 750 mL bottle of white wine is the statement:

**13.5% Alc/Vol**  
**CONTAINS APPROX 8 STANDARD DRINKS**

**Note:** 13.5% Alc/Vol means that every 100 mL of the wine contains 13.5 mL of pure ethanol,  $\text{C}_2\text{H}_5\text{OH}$ . The density of pure ethanol is  $0.790 \text{ g mL}^{-1}$  at room temperature.

- (a) Calculate the mass of ethanol in one 750 mL bottle of the wine at room temperature.

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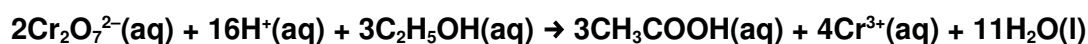
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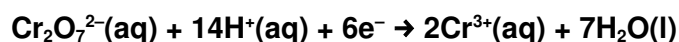
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(3 marks)

Quality control demands that the alcohol content falls within 1% of the quoted value on the bottle. One way to determine the alcohol content in wine involves the oxidation of ethanol to ethanoic acid ( $\text{CH}_3\text{COOH}$ ) using acidified dichromate as the oxidant. The equation for the oxidation of ethanol with dichromate in acid solution is:



The half equation for dichromate as an oxidant is:



(b) Write the half equation for the oxidation of ethanol to ethanoic acid in acid solution.

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(1 mark)

A 10.0 mL sample of white wine was diluted to 250 mL in a volumetric flask. Then 25.0 mL aliquots of the diluted wine were titrated against  $0.0750 \text{ mole L}^{-1}$  acidified potassium dichromate solution ( $\text{K}_2\text{Cr}_2\text{O}_7$ ). The average titre was 20.61 mL.

(c) Calculate the number of mole of ethanol in the 10.0 mL sample of white wine.

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(3 marks)

- (d) Determine whether the alcohol content of this wine falls within the 1% tolerance limit.

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(2 marks)

**Question 43**

**(8 marks)**

Many alcohols are industrially important. They can be used as solvents, disinfectants, preservatives and as reactants in organic syntheses.

Up to  $C_{10}$ , the straight chain alcohols are colourless liquids with characteristic odours at room temperature. The longer chain alcohols are waxy solids. The boiling points of alcohols are considerably higher than for corresponding hydrocarbons. This is particularly true for the shorter chain alcohols. The table below gives the boiling points for some of the shorter chain alcohols.

Alcohol	Boiling point ( $^{\circ}C$ )
Methanol	64.7
Ethanol	78.3
1-propanol	97.2
2-propanol	82.4
1-butanol	117.7
2-butanol	99.5

With reference to the table above discuss the nature and relative strengths of the intermolecular forces in alcohols.

[illegible]

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**END OF EXAMINATION**

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