Year 12 Chemistry 3A/3B Examination, 2010

Question/Answer Booklet

CHEMISTRY

Student Name/Number:	

Section	Mark
1	/50
2	/70
3	/80
Total	/200
	%

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Sheet

To be provided by the candidate

Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set out by the Curriculum Council for this course

Important note to candidates

No other items may be taken into the examination room. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor before reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	25	50	25	25
Section Two: Short answer	12	12	60	70	35
Section Three: Extended answer	5	5	70	80	40
					100

Instructions to candidates

1. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a 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, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. 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.

See next page

Section One: Multiple-choice 25% (25 Marks)

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a 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, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time for this section is 50 minutes.

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1. Which of the following best describes the molecular shape and molecular polarity of a chloroform molecule whose formula is $CHBr_3$?

   (a) pyramidal, non polar

   (b) tetrahedral, non polar

   (c) pyramidal, polar

   (d) tetrahedral, polar

2. An element X has the following five successive ionisation energies (in $kJmol^{-1}$)

   680 1600 8000 11600 14500

   What would be the formula of the compound formed when "X" reacts with oxygen ?

   (a) X_2O

   (b) XO

   (c) X_2O_3

   (d) XO_2

3. When 1.0 mol L^{-1} solutions of the following are mixed, which combinations will result in the formation of precipitates?

   i) $Ba(NO_3)_2$ and HCl
   ii) $Ca(NO_3)_2$ and Na_2CO_3
   iii) $Cu(NO_3)_2$ and KOH
   iv) $Pb(NO_3)_2$ and H_2SO_4

   (a) i), ii) and iii) only

   (b) ii) and iii) only

   (c) i), ii), iii) and iv)

   (d) ii), iii) and iv) only

See next page

4. The conjugate base of the acid $HCrO_4^-$ is:

   (a) H_2CrO_4

   (b) $H_2CrO_4^-$

   (c) CrO_4^{2-}

   (d) CrO_4^-

5. Which of the following physical properties **decrease** with increasing atomic number for both the alkali metals and the halogens?

   I. Atomic radius
   II. Ionization energy
   III. Melting point

   (a) I only

   (b) II only

   (c) III only

   (d) I and III only

6. Which of the following equations represents a redox equation?

   (a) $NaOH + HNO_3 \rightarrow NaNO_3$

   (b) $2AgNO_3 + Cu \rightarrow 2Ag + Cu(NO_3)_2$

   (c) $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

   (d) $CaCl_2 + Ba(OH)_2 \rightarrow Ca(OH)_2 + BaCl_2$

7. Which one of the following solids contains covalent bonds only?

   (a) SiO_2

   (b) MgO

   (c) NH_4Br

   (d) Ne

8. If the pH of a solution changes from 2 to 4, then the hydronium ion concentration

   (a) is doubled.

   (b) is halved.

   (c) increases by a factor of 100.

   (d) decreases by a factor of 100.

See next page

9. A crystal of iodine, I_2, produces a purple vapour when gently heated.
Which pair of statements correctly describes this process?

	Type of bond broken	**Formula of purple species**
(a)	covalent	I
(b)	covalent	I_2
(c)	dispersion forces	I_2
(d)	dipole-dipole	I_2

10. Household bleach contains sodium hypochlorite, NaClO, as the active ingredient. The concentration of NaClO in the bleach can be determined by reacting a known amount with aqueous hydrogen peroxide, H_2O_2, according to the equation:

$$NaClO(aq) + H_2O_2(aq) \rightarrow NaCl(aq) + O_2(g) + H_2O(l)$$

When 25.0 mL of bleach is treated with an excess of aqueous H_2O_2, 0.0350 mol of oxygen gas is given off.

What is the concentration of NaClO in the bleach?

(a) 1.40 mol L^{-1}

(b) 0.700 mol L^{-1}

(c) 0.875 mol L^{-1}

(d) 8.75×10^{-4} mol L^{-1}

11. In the contact process reaction:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g); \qquad \Delta H = -196 \text{ kJ mol}^{-1}$$

If the equilibrium system **temperature** is increased, what effect will this have on the equilibrium constant, K, and the yield?

	Equilibrium constant, K	**Yield increase**
(a)	decrease	products
(b)	decrease	reactants
(c)	increase	products
(d)	increase	reactants

See next page

12. Deposits of ammonium compounds, including ammonium sulfate, have been discovered in areas of high atmospheric pollution. A chemical reaction believed to occur is:

$$SO_3(g) + H_2O(l) + 2NH_3(g) \rightarrow (NH_4)_2SO_4(s)$$

What does **not** occur in this reaction?

(a) acid/base neutralisation

(b) coordinate (dative) bond formation

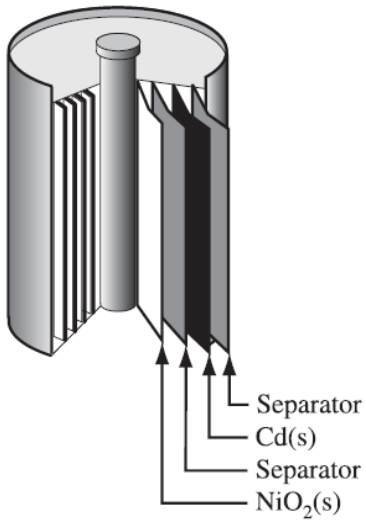
(c) oxidation/reduction

(d) ionic bond formation

See next page

13. Galvanic cells are used as portable sources of electrical energy. One common cell is the rechargeable nickel-cadmium cell.

Nickel–Cadmium Cell



The net equation representing the discharge of the nickel-cadmium cell is:

$$NiO_2(s) + Cd(s) + 2H_2O(l) \rightarrow Cd(OH)_2(s) + Ni(OH)_2(s)$$

The reaction at the **anode** during the discharge of the cell is:

(a) $Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$

(b) $Cd(s) + 2OH^-(aq) + 2e^- \rightarrow Cd(OH)_2(s)$

(c) $NiO_2(s) + 2H_2O(l) + 2e^- \rightarrow Ni(OH)_2(s) + 2OH^-(aq)$

(d) $NiO_2(s) + 2H_2O(l) \rightarrow Ni(OH)_2(s) + 2OH^-(aq) + 2e^-$

14. Which one of the following has the same electronic arrangement as Li^+?

(a) Na^+

(b) Be^{2+}

(c) F^-

(d) Ne

See next page

15. The largest mass of silver chloride is precipitated when an excess of silver nitrate solution is added to:

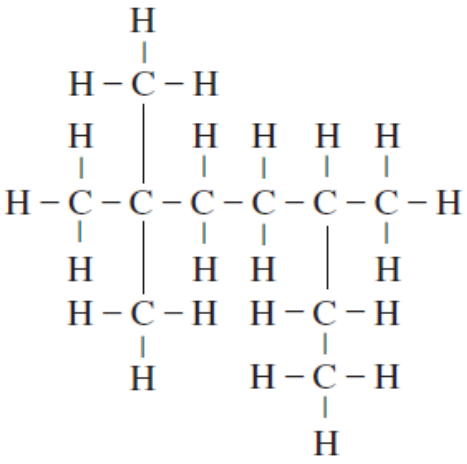
(a) 25.0 mL of a 0.800 mol L^{-1} solution of hydrochloric acid.

(b) 30.0 mL of a 0.300 mol L^{-1} solution of iron(III) chloride.

(c) 50.0 mL of a 0.200 mol L^{-1} solution of magnesium chloride.

(d) 50.0 mL of a 0.500 mol L^{-1} solution of sodium chloride.

16. The IUPAC name for the structure below is:



(a) 2,2,5-trimethylheptane

(b) 3,6,6-trimethylheptane

(c) 2-ethyl-5,5-dimethylhexane

(d) 5-ethyl-2,2-dimethylhexane

17. Which one of the following species does **not** have eight valence electrons surrounding the central atom?

(a) $CHCl_3$ molecule

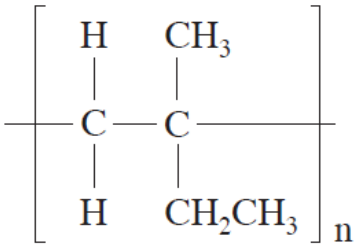
(b) NO_2 molecule

(c) NH_4^+ ion

(d) OF_2 molecule

See next page

18. Select, from the list below, the compound that can be polymerised to give:



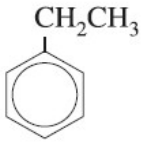
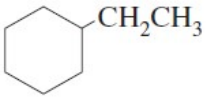
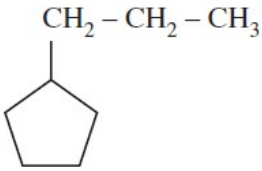
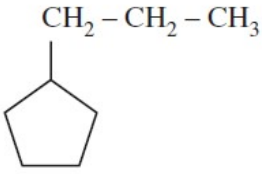
(a) 2-methylbut-1-ene

(b) 2-methylbut-2-ene

(c) pent-2-ene

(d) pent-1-ene

19. Which of the following rows identifies the structural diagram and the corresponding IUPAC name of the compound with the chemical formula, C_8H_{16}?

	Structural Diagram	IUPAC Name
(a)		ethylbenzene
(b)		ethylcyclohexane
(c)		cyclopentylpropane
(d)		propylcyclopentene

See next page

20 When the compounds HF, H_2O, NH_3, and CH_4 are listed in order of increasing boiling point, which order is correct?

(a) $CH_4 < NH_3 < H_2O < HF$

(b) $NH_3 < CH_4 < H_2O < HF$

(c) $CH_4 < NH_3 < HF < H_2O$

(d) $HF < CH_4 < H_2O < NH_3$

21. The reductant that can convert 1.0 M $Fe^{3+}(aq)$ to $Fe^{2+}(aq)$ but not 1.0 M $Sn^{2+}(aq)$ to Sn(aq), at STP is:

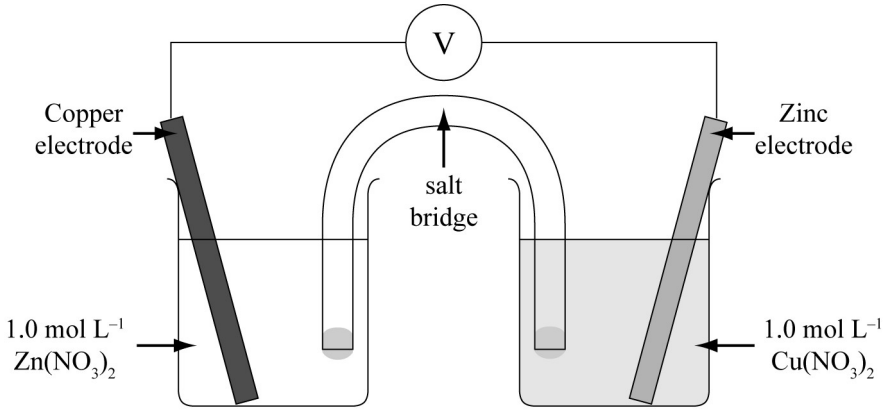
(a) Cu(s)

(b) Au(s)

(c) Ni(s)

(d) HOOCCOOH(l)

22. A cell was incorrectly connected, as shown below. Which statement is **incorrect**?



(a) The anode is the zinc electrode.

(b) There would be no electron current flow from one half cell to the other.

(c) If electrodes are interchanged the cell emf (potential difference) would be -1.1V (at 25 ^oC).

(d) The concentration of Cu^{2+} ions will decrease.

23. Which of the following statements is **correct**?

(a) Covalent network solids include diamond, graphite and sulfur.

(b) Metal solids and ionic solids exhibit non-directional interparticle bonding.

(c) Ionic solids conduct electricity very well in the aqueous and solid states.

(d) Heated covalent molecular solids tend to decompose before melting.

See next page

24. Which of the following statements about the third row of the Periodic Table is correct?

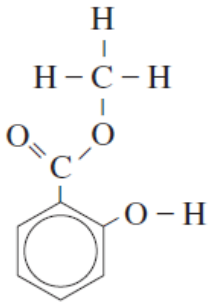
(a) Elements on the right side of the row form acidic oxides, whilst those on the left side form basic oxides.

(b) Elements on the left side of the row have a greater range of oxidation states than elements on the right side.

(c) Elements on the right side of the row are stronger reducing agents than elements on the left side.

(d) Electronegativity decreases across a row from left to right of the period.

25. A common painkiller has the structure:



Which of the options below best represents its characteristics?

	Type	**Functional groups**
(a)	aromatic	carboxyl, hydroxyl
(b)	aliphatic	hydroxyl, alkene
(c)	aromatic	hydroxyl, ester
(d)	aliphatic	carbonyl, hydroxyl

End of Section One

See next page

Section Two: 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.

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Suggested working time for this section is 60 minutes.

Question 26 **(5 marks)**

A buffer solution is needed for preserving "Tango" fruit juice. A chemist at the fruit juice company prepared a benzoic acid/sodium benzoate buffer with concentrations of 0.105 mol L^{-1} C_6H_5COOH and 0.125 mol L^{-1} C_6H_5COONa.

(a) What is a "buffer solution", and what is its purpose? (2 mark)

(b) Explain, using Le Chatelier's principle, how this solution acts as a buffer solution. (use equations in your answer). (3 marks)

Question 27 **(2 marks)**

Toluene (methyl benzene), C_7H_8 (g) is an important solvent and precursor to many other organic compounds such as trinitrotoluene (TNT). It can be produced according to the following equilibrium:

$$C_7H_{14}(g) \rightleftharpoons C_7H_8(g) + 3H_2(g)$$

When 3.00 mol of C_7H_{14} (g) was introduced into a 1.00 L container, 1.20 mol of H_2(g) was produced at equilibrium.

See next page

What were the equilibrium concentrations, in mol L^{-1}, of C_7H_8 and C_7H_{14}?

Question 28 **(4 marks)**

Write **observations** for any reactions that occur in the following procedures. In each case describe in full 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) Potassium sulfide solution is added to lead (II) nitrate solution. (2 marks)

Observation:

(b) Sodium metal is added to pentanol. (2 marks)

Observation:

Question 29 **(3 marks)**

(a) Consider the reaction half equations and then balance the following redox equation:

$$\_\_Cl_2(aq) + \_\_S_2O_3^{2-}(aq) + \_\_H_2O(aq) \rightarrow \_\_SO_3^{2-}(aq) + \_\_H^+(aq) + \_\_Cl^-(aq)$$

(2 marks)

See next page

(b) Re-write the redox equation, for alkaline (basic) conditions. (1 mark)

See next page

Question 30 **(4 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 $Ag^+(aq)$], molecules [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(\square)$] or solids [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

(a) Potassium phosphate solution is added to copper (II) sulfate solution. (2 marks)

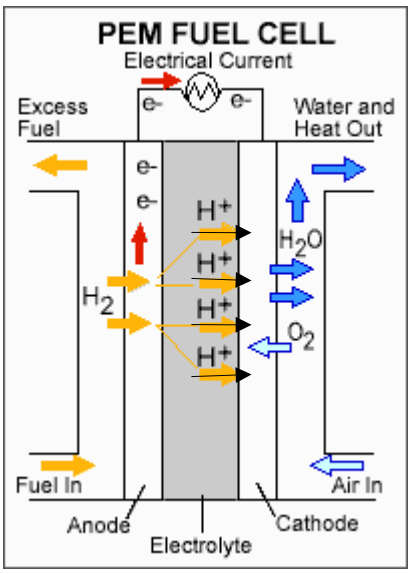
Equation: _____

(b) Sulfur trioxide gas is bubbled through a sodium oxide solution. (2 marks)

Equation: _____

Question 31 **(7 marks)**

Commercial buses, and cars, can operate using a proton exchange membrane fuel cell (PEM) to provide the required energy. They use a solid polymer sandwiched between two sheets of carbon fibre paper as an electrolyte, and porous carbon electrodes containing a platinum catalyst. They need only hydrogen, oxygen from the air, and water to operate. They are typically fuelled with pure hydrogen supplied from storage tanks or onboard reformers. The cell operates at a temperature of around 80°C.



A Picture of the Hydrogen Fuel Cell Transit Bus

(a) What is **one** advantage of a solid polymer membrane electrolyte over the liquid chemical electrolyte, KOH (used in other fuel cells)? (1 mark)

_____

_____

_____

(b) State **one** environmental advantage, and **one** sustainability advantage; of this PEM fuel cell over the use of conventional fuels such as diesel? (2 marks)

_____

See next page

_____

_____

See next page

(c) What are **two** disadvantages of the O_2/H_2 fuel cell, as energy sources, over conventional fuels such as diesel? (2 marks)

(d) Some fuel cells use methanol as a source of hydrogen (as H^+), which combines with oxygen to produce carbon dioxide and water. Write half equations and then a balanced redox equation for this process. (2 marks)

Question 32 **(8 marks)**

On heating, a mixture of potassium and bromine react to form potassium bromide, according to the equation: $2K(s) + Br_2(l) \rightarrow 2KBr(s)$

(a) The melting points of potassium, bromine and potassium iodide are 63.3 °C, -7.2 °C and 734 °C respectively. For each of the substances state the type of **inter-particle** bonding present and the nature of the attractive forces holding each substance together. (6 marks)

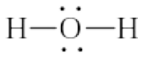
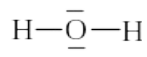
Substance	**Type of bonding**	**Nature (strength) of bonding**
Potassium		
Bromine		
Potassium bromide		

(b) Briefly explain why the melting point of bromine is much lower than that of sodium bromide. (2 marks)

See next page

Question 33 **(15 marks)**

(a) For each species listed in the table below, draw the structure, representing all valence shell electron pairs either as **:** or as — **and** state or draw the shape of the molecule or ion. (9 marks)

(for example, water  or  or  bent)

Compound	Electron-dot structure (showing all valence shell electrons)	Shape (sketch or name)
Carbon disulfide CS_2		
Strontium nitrate $Sr(NO_3)_2$		
Diaminomethanone NH_2CONH_2 (“urea”)		

See next page

(b) Compare, and explain, the molecular polarity of carbon disulfide and urea. (6 marks)

Compound	**Polar or non-polar**	**Explanation**
CS_2		
H_2NCONH_2		

Question 34 **(5 marks)**

(a) **Draw** and **label** the <u>geometric</u> isomeric forms of 2-pentene (pent-2-ene). (3 marks)

Form:	Form:

(b) What chemical test could be used to distinguish between pent-2-ene and pentane? (chemical equation required) (2 marks)

See next page

Question 35 **(10 marks)**

Industrially, calcium carbonate can be thermally decomposed (roasted) to form calcium oxide ('quicklime"). This product is used to change pH, in calcium silicate brick manufacture, in aluminium and gold production, and in the building industry (plaster).

The chemical reaction for its production is:

$CaCO_3(s)$ + heat $\rightleftharpoons$ $CaO(s)$ + $CO_2(g)$

(a) What is the K_{eq} expression for the reaction? (1 mark)

(b) In practice, conditions can be changed to alter the rate of reaction and the yield of product. Indicate any effects of imposed change on the system in the table below.
(9 marks)

Imposed change	**Initial forward reaction rate** (increase, decrease, or no effect)	**Initial reverse reaction rate** (increase, decrease, or no effect)	**Effect on new equilibrium position** (to right →, to left ←, or no effect)
Increase the partial pressure of the carbon dioxide			
The temperature in decreased			
Increase surface area of the $CaCO_3$			

See next page

Question 36 **(3 marks)**

Older second hand cars can have bubbling of paint on the panels during to iron corrosion ("rusting") under the sealed paint (i.e. an anodic region). This is often noticed close to the wheel hubs or the base of doors or windows. The paint under normal circumstances provides a physical barrier to corrosion.

(a) What is the likely cause of the corrosion? (2 marks)

(b) Suggest a practical chemical solution to the problem. (1 mark)

Question 37 **(4 marks)**

(a) Illustrate the backbone structure of a **silicone**. (1 mark)

(b) Silicones don't exhibit hydrogen bonding yet are able to form rigid structures. What is this due to? (1 mark)

(c) Explain **one** useful property of a silicone. (2 marks)

See next page

End of Section Two

Section Three: Extended answer **40% (80 Marks)**

This section contains **five (5)** questions. You must 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.

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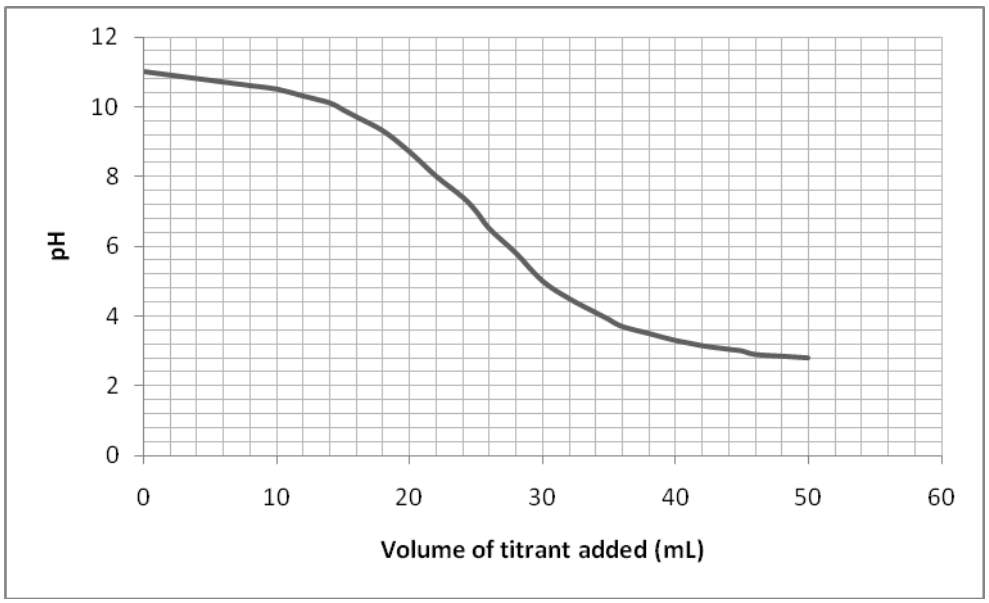
Suggested working time for this section is 70 minutes.

Question 38 **(14 marks)**

A student carried out two acid-base practical investigations, at 25°C:

A titration was performed where 20.0 mL of an unknown solution was pipetted into a conical flask and titrated with another unknown solution from a burette. The pH was monitored with a pH meter, recorded with a data logger and the results displayed on a computer screen throughout the experiment. The changes in pH are shown below:



(a) What is meant by the term “equivalence point”? (1 mark)

See next page

(b) What was the pH of the mixture at the equivalence point? (1 mark)

(c) (i) A pH meter had to be used in this investigation. Explain, why there was no suitable acid-base indicator that could be used for this titration? (1 mark)

(ii) What does this tell us about the acid and base added together? (1 mark)

(iii) Give an example of the acid and base that could have been used to give these results? (1 mark)

Acid_____ Base_____

(iv) Which species was in the conical flask? (1 mark)

(e) What was the concentration of $OH^-(aq)$ (mol L^{-1}) in the mixture after 15.0 mL of titrant had been added? (2 marks)

A commercial brand of antacid, “Easiflux”, was tested to see how much acid it could neutralize. A 5.00 mL sample of the mixture was used where the active ingredient was stated to be magnesium hydroxide, $Mg(OH)_2$. The mixture was reacted with 12.90 mL of 72.9 g L^{-1} hydrochloric acid, HCl (stomach acid).

(f) Write a balanced formula equation for this reaction. (1 mark)

See next page

(g) How many moles of HCl reacted? (2 marks)

(h) What mass (g) of magnesium hydroxide would react with this amount of HCl? (2 marks)

(i) The suggested dose for bad indigestion is 800 mg of $Mg(OH)_2(s)$ in a 5.00 mL dose. How does the sample tested compare with this? (1 mark)

Question 39 **(17 marks)**

There are many ways of observing and measuring the rates of chemical reactions. A student investigated one reaction involving colour change; an "iodine clock" reaction.
At room temperature, a reaction occurs when potassium iodate solution is mixed with sodium hydrogen sulfate solution that contains a small amount of starch. In a laboratory, 12.00 mL of a 0.0160 M $NaHSO_3$ (aq) solution containing starch were placed in each of six test tubes. Different volumes of 0.0240 M KIO_3 (aq) and enough distilled water to maintain a constant volume were added to each test tube and the time taken for the dark-blue colour to appear was measured. The data were recorded in the table over the page.

(*a*) The chemical reaction was:

$5HSO_3^-(aq) + 2IO_3^-(aq) \rightarrow I_2(s) + 5SO_4^{2-}(aq) + H_2O(aq) + 3H^+(aq)$

What is the "dark-blue" colour due to? (1 mark)

(b) Is this a redox reaction? Justify your answer. (2 marks)

(b) Describe a procedure for diluting the stock 0.0240 mol L^{-1} KIO_3 solution to give a 0.00800 mol L^{-1} reaction mixture test solution. (2 marks)

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(c) What is the independent variable for the investigation? (1 mark)

(d) What variables need to be controlled? (1 mark)

(e) Complete the table below, and graph the data of reaction rate (1/t) versus concentration of potassium iodate (mol L^{-1}). (5 marks)

Concentration of IO_3^- (mol L^{-1}) in reaction mixture.	**Reaction time (s).**	**Reaction rate, 1/t (s^{-1}).**
0.00200	210	
0.00400	88	
0.00600	49	
0.00800	39	
0.0100	33	
0.0120	27	

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(f) What conclusion can be drawn from the graph about the relationship between the rate of the reaction and the concentration of the potassium iodate? (1 mark)

(e) Use your graph to predict the time taken for a 0.00500 mol L^{-1} potassium iodate solution, at standard room temperature, to react. (1 mark)

(f) The procedure described above was repeated at a number of different temperatures between 10 ºC and 70 ºC and the reaction times were measured as before. Would you expect the reaction times to increase, decrease, or stay the same, as the temperature was increased? Use Collision Theory to justify your answer.

(3 marks)

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Question 40 **(15 marks)**

Iron in one of the most abundant metals on Earth, is essential to most forms of life and to normal human physiology. Sometimes people take iron supplements. The iron content of a particular brand of iron tablets was determined by titration with a freshly standardised solution of potassium permanganate, $KMnO_4$. The equation for the titration reaction is:

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$

(a) Why are iron tablets sometimes medically prescribed? (1 mark)

(b) What is the oxidation number of manganese in the permanganate ion? (1 mark)

(c) (i) Why must potassium permanganate solutions be standardised? (2 mark)

(ii) What reagent is used for this purpose? (1 mark)

250 mL of Fe^{2+} solution was prepared from ten (10) iron tablets, each of mass 0.328 g.

(e) Explain why additional dilute sulfuric acid must be added to the titration flask before each titration is carried out. (1 mark)

(f) How was the end-point detected? (1 mark)

A standardised 0.0100 M potassium permanganate was used to react with 25.0 mL portions of the iron solution prepared from the ten tablets.

(g) A number of titrations were performed and the following titre values obtained.

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Titre (mL)	21.00	18.79	18.76	17.45	18.70

What is the average titre used? (1 mark)

(g) What is the **concentration** (mol L^{-1}) of the Fe^{2+} solution? (3 marks)

(h) What is the **total mass** (mg**)** of iron in <u>one</u> tablet? (3 marks)

(i) What is the **percentage, by mass**, of iron in each tablet? (1 mark)

Question 41 **(22 marks)**

Many drugs are produced by chemically combining several molecules. A newly developed amino acid, in combination with another substance, has the potential to be a new ant-inflammatory drug. The structure of the amino acid (Mr = 179.214) is:

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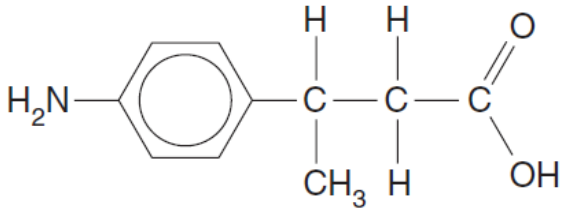


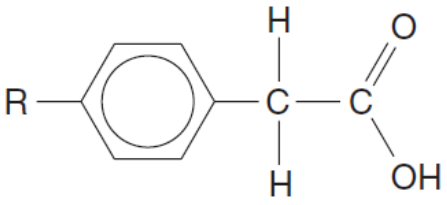
(a) (i) Explain, why it is considered to be an amino acid? (2 marks)

(ii) State the general formula of an α-amino acid. Explain whether or not the above amino acid fits this category. (2 marks)

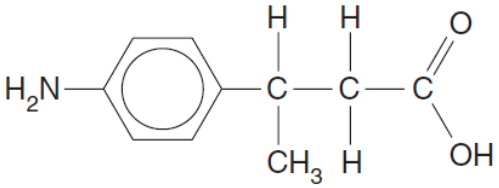
The amino acid above exists as a zwitterion in aqueous solution.

(b) Draw the structure of this **zwitterion**. (2 marks)

The anti-inflammatory drug is made by combining the amino acid, with the molecule shown below, called compound **X**. R represents a small side chain.



Compound "X"



Amino acid

(c) (i) Combine both structures to show the structure of the **drug**. (1 mark)

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(ii) What type of chemical linkage forms? (1 mark)

(iii) What type of reaction occurs, and what small molecule is released? (2 marks)

(d) Spectroscopy analysis showed compound **X** contained the elements C, H, O, and chlorine (Cl).
Experimentally, the identity of R was found by combusting 0.425 g of compound **X** in excess air. It was found that 0.912 g of carbon dioxide and 0.187 g of water was produced.

Further testing of a further 0.396 g sample of compound **X,** produced 27.9 mL of chlorine gas (Cl_2), under conditions of 40 ^oC and 100 kPa.

(i) Determine the **percentage composition**, by mass, of each element in compound **X**. (7 marks)

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(ii) Determine the **empirical formula** of compound **X**. (2 marks)

(iii) What is the **molar mass** of compound **X**? (1 mark)

(iv) What is the **identity** of the side branch, **R**? (2 marks)

Question 42 **(12 marks)**

Butanoic acid, $CH_3CH_2CH_2COOH$, is a ubiquitous, oily, colourless substance with a diverse range of origins and uses. It occurs naturally but can be manufactured through the fermentation of sugar and starch, and then the addition of putrefying cheese, with calcium carbonate added to neutralize the acid.

(a) **Draw** and **name** two structural isomers of $C_4H_8O_2$ (other than butanoic acid). (4 marks)

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Name:
Name:

Butanoic acid is a rancid smelling substance that gives parmesan cheese its characteristic odour. It has been used as a nausea inducing repellent by anti-whaling protesters against whalers. Butanoic acid can undergo **esterification** with ethanol, CH_3CH_2OH, to form a much more pleasant smelling pineapple flavoured ester.

(b) What is the common **catalyst** used for this reaction? (1 mark)

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(c) Draw, and name the **ester** formed. (2 marks)

Name:

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The perspiration stains in clothes are partly due to the presence of butanoic acid. Soap powders form alkaline solutions, often containing sodium carbonate, which are used to neutralise this
acidity.

Fats and oils can be removed from clothing by the action of soaps and detergents. Soaps are typically sodium or potassium salts of long chain fatty acids e.g. $CH_3(CH_2)_{16}COONa$, whereas detergents are alkylbenzenesulfonate substances e.g. $CH_3(CH_2)_{11}C_6H_4SO_3Na$.

(d) Discuss, with illustrations, the action of soaps **or** detergents. Use the terms:

- dispersion forces
- surfactant (or emulsifying agent)
- polar and non-polar
- hydrophobic and hydrophilic
- micelle (5 marks)

End of questions

Additional working space

Additional working space