SCOTCH COLLEGE

Semester Two Examination, 2018

Question/Answer Booklet

CHEMISTRY
Year 11

Student Name/Number:	

Section	**Mark**
One	/50
Two	/70
Three	/60
Total	/180
	%

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

Material required/recommended for this paper

To be provided by the supervisor
Question/Answer booklet
Chemistry Data Book

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority 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 unauthorized notes or other items of a non-personal nature in the examination room. If you have any unauthorized 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	50	28
Section Two: Short answer	11	11	70	70	39
Section Three: Extended answer	4	4	60	60	33
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 11 Information Handbook 2018*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Section One: Answer all questions on the multiple-choice answer sheet on page 9. 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 then shade your new answer. Do not erase or use correction fluid/tape. 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 your answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to three significant figures and include appropriate units where applicable.

4. 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.

5. 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 question(s) that you are continuing to answer at the top of the page.

Section One: Multiple-choice 28% (50 marks)

This section has **25** questions. Answer **all** questions on the Multiple-choice Answer Sheet provided – page 9. 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 then shade your new answer. Do not erase or use correction fluid/tape. 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: 50 minutes.

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1. Which of the following statements about subatomic particles is **false**?

   (a) Protons and neutrons have approximately the same mass.
   (b) Protons and electrons have equal and opposite charge.
   (c) Protons and neutrons make up most of the mass of an atom.
   (d) Protons and neutrons will be equal in number in any neutral atom.

2. Two atoms, Q and R, have the electron configurations 2,2 and 2,8,8,7. Which of the following statements is **true**?

   (a) The compound formed between Q and R is likely to have a high melting point.
   (b) R is likely to conduct electricity in the liquid state.
   (c) Q and R are unlikely to react with other elements.
   (d) Elements Q and R would form covalent bonds with one another.

3. Which of the following solutions is likely to have the **highest** pH?

   (a) 1 mol L^{-1} NaOH(aq)
   (b) 1 mol L^{-1} NH_3(aq)
   (c) 1 mol L^{-1} Na_2CO_3(aq)
   (d) 1 mol L^{-1} CH_3COOH(aq)

4. Which one of the following best describes the molecular shape, polarity of bonds and the molecular polarity of a $CC\ell_4$ molecule?

	Shape	Bond polarity	Molecular polarity
(a)	tetrahedral	non-polar	polar
(b)	tetrahedral	polar	polar
(c)	pyramidal	non-polar	polar
(d)	tetrahedral	polar	non-polar

5. Which of the following common substances can be described as a homogenous mixture?

(a) Concrete
(b) Limestone
(c) Stainless steel
(d) Copper

6. Germanium is an element that exists as a covalent network. Which of the following statements **best** explains why germanium melts at a high temperature (938°C)?

(a) There are strong electrostatic attractions between germanium ions and delocalized electrons.
(b) There are strong electrostatic attractions between germanium atoms and shared pairs of electrons.
(c) There are strong intramolecular bonds between oppositely charged germanium ions.
(d) There are strong intermolecular forces between germanium atoms.

7. In which of the following experiments would no visible observation be made?

(a) Solid potassium nitrate is shaken with distilled water.
(b) A small piece of sodium is placed in water.
(c) Solid calcium carbonate is added to dilute hydrochloric acid.
(d) Sodium carbonate solution is mixed with ammonium nitrate solution.

8. Two solutions, A and B, have a pH of 3 and 6 respectively. Which of the following statements about the solutions must be **true**?

(i) They are both acidic.
(ii) The concentration of H^+ is higher in B than it is in A.
(iii) B is a weaker acid than A.

(a) (i) only
(b) (ii) only
(c) (i) and (iii) only
(d) (i), (ii) and (iii)

9. In which one of the following is more than one type of intermolecular force acting?

(a) $Br_2(s)$
(b) $SO_2(s)$
(c) $CH_4(s)$
(d) $CO_2(s)$

10. Which of the following lists of oxides would all produce alkaline solutions when dissolved in water?

(a) CO_2, SiO_2, CaO
(b) CaO, Na_2O, P_4O_{10}
(c) K_2O, CaO, Na_2O
(d) P_4O_{10}, SO_2, CO_2

11. Ammonia is classed as a weak electrolyte. Which of the following statements **best** explains this?

(a) Only a small proportion of ammonia molecules will be form ions in solution.
(b) The pH of ammonia solutions is quite low compared to other bases.
(c) Ammonia is not very soluble in water.
(d) Ammonia is a covalent molecule, so its solution will not have any ions.

12. Which one of these molecular chemical equations correctly shows the reaction (including state symbols) when dilute solutions of sodium hydroxide and ammonium chloride are mixed at 20°C?

(a) $NaOH(s) + NH_4C\ell(aq) \rightarrow NaC\ell(aq) + NH_4OH(aq)$
(b) $NaOH(aq) + NH_4C\ell(aq) \rightarrow NaC\ell(aq) + H_2O(\ell) + NH_3(g)$
(c) $NaOH(\ell) + NH_4C\ell(\ell) \rightarrow NaC\ell(aq) + HC\ell(\ell) + NH_3(\ell)$
(d) $NaOH(aq) + NH_3C\ell(aq) \rightarrow NaC\ell(aq) + H_2O(g) + NH_3(g)$

13. In which of the following equations is water acting as an acid?

(a) $2\ K(s) + 2\ H_2O(\ell) \rightarrow 2\ KOH(aq) + H_2(g)$
(b) $NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
(c) $H_2CO_3(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$
(d) $HC\ell(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + C\ell^-(aq)$

14. Which of the following statements is generally true of elements in the Periodic Table?

(a) Ionization energy increases down a group
(b) atomic radii increase across a period
(c) group 1 elements become more metallic as the atomic number increases
(d) electronegativity increases down a group

15. Which of the following reactions is endothermic?

(a) $Br_2(g) \rightarrow 2\ Br(g)$
(b) $N_2(g) \rightarrow N_2(\ell)$
(c) $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$
(d) $H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$

16. Ethanol (C_2H_5OH) has a boiling point just over 78°C. Which of the following statements is **true**?

(a) Ethanol has stronger intermolecular forces than water.
(b) Adding an impurity to ethanol would make it evaporate more quickly.
(c) The vapour pressure of ethanol at 100°C would be greater than that of an aqueous solution of sodium chloride.
(d) The bonds in ethanol must be weaker than those in water.

17. In which of the following pairs are the two substances shown isomers of one another?

(a) heptane and 3-ethylhexane
(b) 1-butene and methylpropane
(c) 1,2,3-tribromobutane and 1,1,2-tribromoprop-1-ene
(d) 1,2-dimethylcyclohexane and 1-octene

18. 10 g of argon gas is placed in a sealed syringe at 50°C. The temperature is lowered to 25°C, and the syringe compressed to half its original volume. Which of the following statements is **true** after the changes are made?

(a) All the argon particles are moving more slowly, and the pressure inside the syringe has dropped.
(b) Some of the argon particles are moving more slowly, and the pressure inside the syringe is unchanged.
(c) All the argon particles are moving more slowly and the pressure inside the syringe is unchanged.
(d) Some of the argon particles are moving more slowly and the pressure inside the syringe has risen.

19. Which of the following aqueous solutions contains the **greatest overall** concentration of ions?

(a) 0.25 mol L^{-1} calcium nitrate
(b) 0.50 mol L^{-1} lithium sulfate
(c) 0.25 mol L^{-1} iron(III) chloride
(d) 0.50 mol L^{-1} sodium chloride

20. What mass of copper(II) chloride would need to be dissolved in 500 mL of distilled water to produce a solution with a concentration of 0.0500 mol L^{-1}?

(a) 2.47 g
(b) 3.36 g
(c) 4.95 g
(d) 6.72 g

21. Which of the following pairs of substances or ions can be described as a conjugate pair according to the Brønsted-Lowry theory of acids and bases

(i) HS^- and H_2S
(ii) H_2SO_4 and SO_4^{2-}
(iii) OH^- and O^{2-}
(iv) HCO_3^- and H_2CO_3

(a) (i) and (ii) only
(b) (iii), and (iv) only
(c) (i), (iii) and (iv) only
(d) (i), (ii), (iii) and (iv)

22. In which of the following substances are there **no** covalent bonds present in the solid lattice?

(a) SO_2
(b) $SrSO_3$
(c) SiO_2
(d) SrO

23. Aluminium is ductile and malleable. Which of the following statements **best** explains these properties?

(a) The forces between aluminium atoms are weak, but can operate over relatively long distances.
(b) Aluminium ions are bonded in layers, with strong bonds within layers and weak forces between one layer and the next.
(c) Aluminium ions will attract one another regardless of their orientation, and so the bonds in the metal lattice will not break when it changes shape.
(d) Delocalised electrons are able to move freely amongst the ions, meaning that metallic bonds are equally strong in all directions.

24. Copper(II) sulfate pentahydrate ($CuSO_4.5H_2O$) has a solubility of 320 g L^{-1} at 20°C. A saturated solution is made by dissolving 400 g of $CuSO_4.5H_2O$ in 1 L of distilled water at 20°C. The mixture is then heated to evaporate some of the water and cooled back to 20°C. Which of the following statements about the resulting mixture is **false**?

    (a) There would be more solid present than in the original mixture.
    (b) The concentration of the resulting solution would be higher than that of the original solution.
    (c) The solution would be blue in colour.
    (d) At least 80 g of solid could be recovered by filtering the mixture.

25. Which of the following statements **best** explains the effect of an increase in temperature on the rate of a chemical reaction?

    (a) Increasing the temperature increases the average kinetic energy of particles, meaning that the fraction of collisions exceeding the activation energy will increase.
    (b) Increasing the temperature causes the particles to move faster and collide with each other more often.
    (c) Increasing the temperature increases the average speed of the particles, meaning there is a better chance of them colliding in the correct orientation.
    (d) Increasing the temperature causes the activation energy of the process to decrease, meaning a greater proportion of collisions will lead to a reaction.

End of section one

Multi-choice answer sheet

	a)	b)	c)	d)
1				
2				
3				
4				
5				
6				
7				
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24				
25				

Mark one response per question with an “X”

Section Two: Short answer **39% (70 Marks)**

This section has **11** questions. Answer **all** questions. Write your answers in the space provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to **three significant figures and include appropriate units** where applicable.

Do not use abbreviations, such as 'nr' for 'no reaction', without first defining them.

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: 70 minutes.

Question 26 **(6 marks)**

The following question involves naming and writing formula of compounds.

(a) Complete the table below by writing the formula of each of the compounds listed. (3 marks)

Name of compound	Formula of compound
hydrogen peroxide	
chromium(III) bromide	
aluminium carbonate	

(b) Complete the table below by writing the name of each of the compounds listed. (3 marks)

Formula of compound	Name of compound
$(NH_4)_2SO_4$	
SF_6	
$CHC\ell_3$	

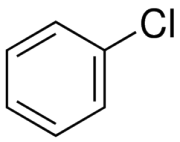
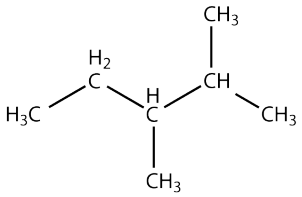
Question 27 **(15 marks)**

(a) Draw the full structure and give the IUPAC names of four <u>non-cyclic</u> isomers of $C_3H_4F_2$. You do not need to draw all possible isomers to gain full marks.

(8 marks)

Structure	IUPAC Name

(b) State the IUPAC name for each of the organic compounds whose structures are represented in the following table. (2 marks)

Structure	IUPAC Name
	
	

(c) Explain why 2-butene is able to exist as geometric isomers, whilst 1-butene is not. (3 marks)

(d) State the intermolecular force(s) in the first compound in part b). (2 marks)

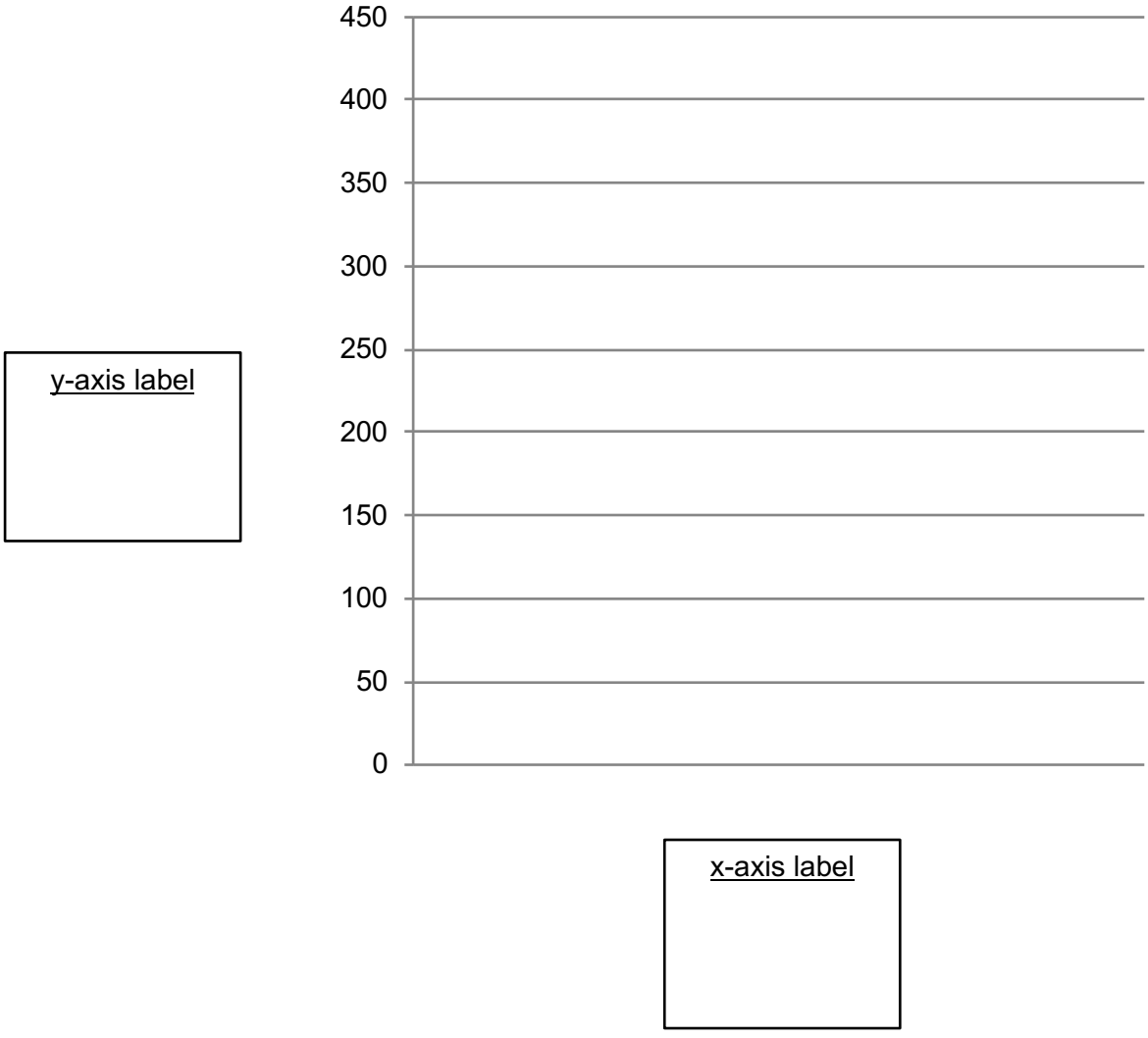
Question 28 **(9 marks)**

Two substances, X and Y, react to produce Z according to the following equation:

$$2\ X(g) + Y(g) \rightarrow Z(g) \quad \Delta H = -100\ kJ\ mol^{-1}$$

It is found that the activation energy for the reaction is 200 kJ mol^{-1}.

(a) Using the axes provided below, sketch the reaction profile for the reaction, assuming that enthalpy of the reactants is 200 kJ mol^{-1}. Ensure that you provide a title for the x and y axes in the box provided, and that you label your sketch clearly. (4 marks)



The reaction is carried out again in the presence of a fine platinum mesh. The reaction is observed to proceed much more rapidly, and the platinum is found unchanged at the end of the reaction.

(b) On the same axes as those used in part (a), add a sketch to show the effect of the platinum. Label this 'Pt'. (1 mark)

(c) Use collision theory to explain the effect that platinum has on the rate of reaction. (2 marks)

(d) State and explain what observations would be made, regarding the rate of reaction, if the reaction were carried out again using platinum beads instead of the fine mesh. (2 marks)

Effect on rate (increase, decrease or no change)	**Explanation**

Question 29 **(3 marks)**

Complete the table below by writing the electron configuration of the atoms or ions listed.

Atom or ion	Electron configuration
A sulfur atom	
The 2- charged ion of the element in group 16, period 3	
An isotope of nitrogen whose nucleus contains 8 neutrons	

Question 30 **(4 marks)**

Iron exists as four naturally occurring isotopes. Considering the lightest of these, ^{54}Fe:

(a) how many neutrons are there in an atom? (1 mark)

_____

(b) what is the mass number? (1 mark)

_____

Carbon forms numerous oxides and ions containing oxygen, such as CO, CO_2 and CO_3^{2-}.

(c) How many protons are there in a molecule of CO_2? (1 mark)

_____

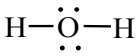
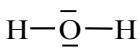
(d) How many electrons are there in a carbonate ion (CO_3^{2-})? (1 mark)

_____

Question 31 **(4 marks)**

For each of the species listed in the table below, draw electron dot diagrams and describe their shape.

Show all valence shell electron pairs either as : or as —

(for example, water  or  or )

Species	Electron dot diagram	Shape
SO_3^{2-}		
C_2H_2		

Question 32 **(6 marks)**

Account for the following observations.

(a) The temperature of water in a beaker is observed to fall as the water evaporates. (3 marks)

(b) Copper is an excellent conductor of electricity in the solid state, whereas solid copper chloride is an electrical insulator. (3 marks)

Question 33 **(9 marks)**

Give balanced ionic equations for any reactions which occur in the following experiments. If no reaction occurs then write 'no reaction'.

In each case describe observations such as colour changes, precipitate formation (give the colour), or gas evolution (give the colour or describe as colourless) resulting from the chemical reaction. If no visible change occurs then you should state this.

(a) A spatula full of sodium oxide is placed in a test tube of dilute nitric acid. (3 marks)

Equation _____

Observation _____

_____

(b) Silver nitrate solution is added dropwise to a beaker of dilute hydrochloric solution. (3 marks)

Equation _____

Observation _____

_____

(c) Bromine water is added to Propene (C_3H_6). (3 marks)

Equation _____

Observation _____

_____

Question 34 **(4 marks)**

First stated by Joseph Gay-Lussac around the end of the 18th century, Gay-Lussac's law states "the pressure exerted by a gas in a sealed container is directly proportional to its temperature". In common with other laws stated around the same time, Gay-Lussac's law works well for so-called 'ideal' gases, but there are conditions under which real gases do not obey the laws particularly well.

(a) Explain why the pressure of a gas should increase as the temperature increases. (2 marks)

_____

_____

_____

_____

_____

_____

(b) Give two reasons why the behaviour of real gases deviate from ideal gas behaviour. (2 marks)

_____

_____

_____

_____

_____

Question 35 **(4 marks)**

For each of the following descriptions, give the name or formula of a substance that matches the description

(a) A weak diprotic acid. _____

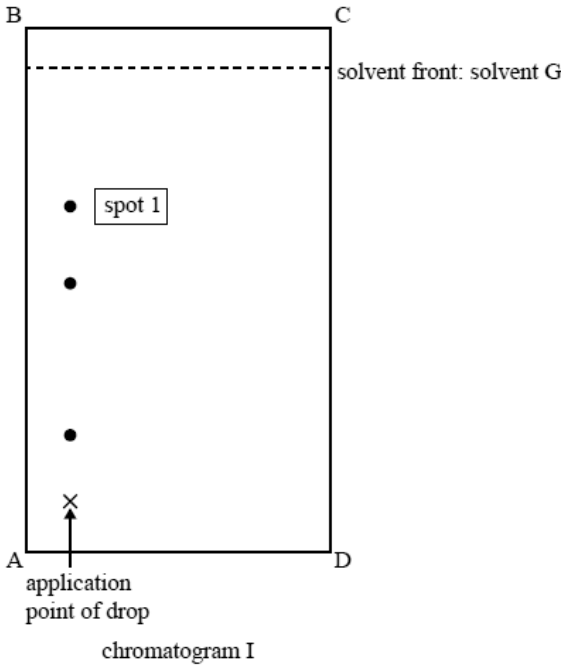
(b) A substance that has ionic and covalent bonds. _____

(c) An acidic oxide with two oxygens in the compound. _____

(d) A branched hydrocarbon with the formula C_4H_{10} . _____

Question 36 **(6 marks)**

Two analytical methods used in chemistry are Chromatography and Mass Spectroscopy.
A drop that contains a mixture of amino acids was applied to a Thin Layer Chromatography (T.L.C.) plate. The plate was placed in a solvent G and the following chromatogram obtained



chromatogram I

(a) Calculate the R_f for spot 1. (2 marks)

_____

_____

_____

(b) Which amino acid is attracted to the mobile phase the most (circle a dot) and explain why you chose this one? (2 marks)

_____

_____

_____

(c) In Mass Spectroscopy state two factors that will determine the amount of deflection.

_____ _____

(2 marks)

End of section two

Section Three: Extended answer 33% (60 marks)

This section contains **four (4)** questions. Answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression.

Final answers to calculations should be expressed to **three (3) significant figures**.

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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- 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: 60 minutes.

Question 37 **(25 marks)**

Chlorine is an element that is found in several acids. The acids are shown in the table below.

Name and formula of acid	Strong/Weak
hydrochloric acid $HC\ell$	strong
hypochlorous acid $HOC\ell$	weak
chlorous acid $HC\ell O_2$	weak
chloric acid $HC\ell O_3$	strong
perchloric acid $HC\ell O_4$	strong

(a) The pH of a solution of perchloric acid was found to be 2. What was the concentration of the solution in g L^{-1}? (3 marks)

_____

_____

_____

_____

_____

Question 37 (continued)

Hypochlorous acid and hydrochloric acid are both formed when chlorine is dissolved in water.

(b) Write the balanced chemical equation for this reaction. (2 marks)

(c) Draw the structural (electron-dot) diagram for hypochlorous acid and use partial charges to show the polarity of the molecule. (2 marks)

(d) Using appropriate equations to illustrate your answer, explain how you would expect the pH of a 0.001 mol L^{-1} solution of hypochlorous acid to compare with the pH of a 0.001 mol L^{-1} solution of hydrochloric acid. (4 marks)

In an experiment to investigate the reactions of hydrochloric acid with metals, a student decided to react the acid with zinc granules and measure the mass lost over a period of time.

(e) Write a balanced ionic equation to show the reaction taking place. (2 marks)

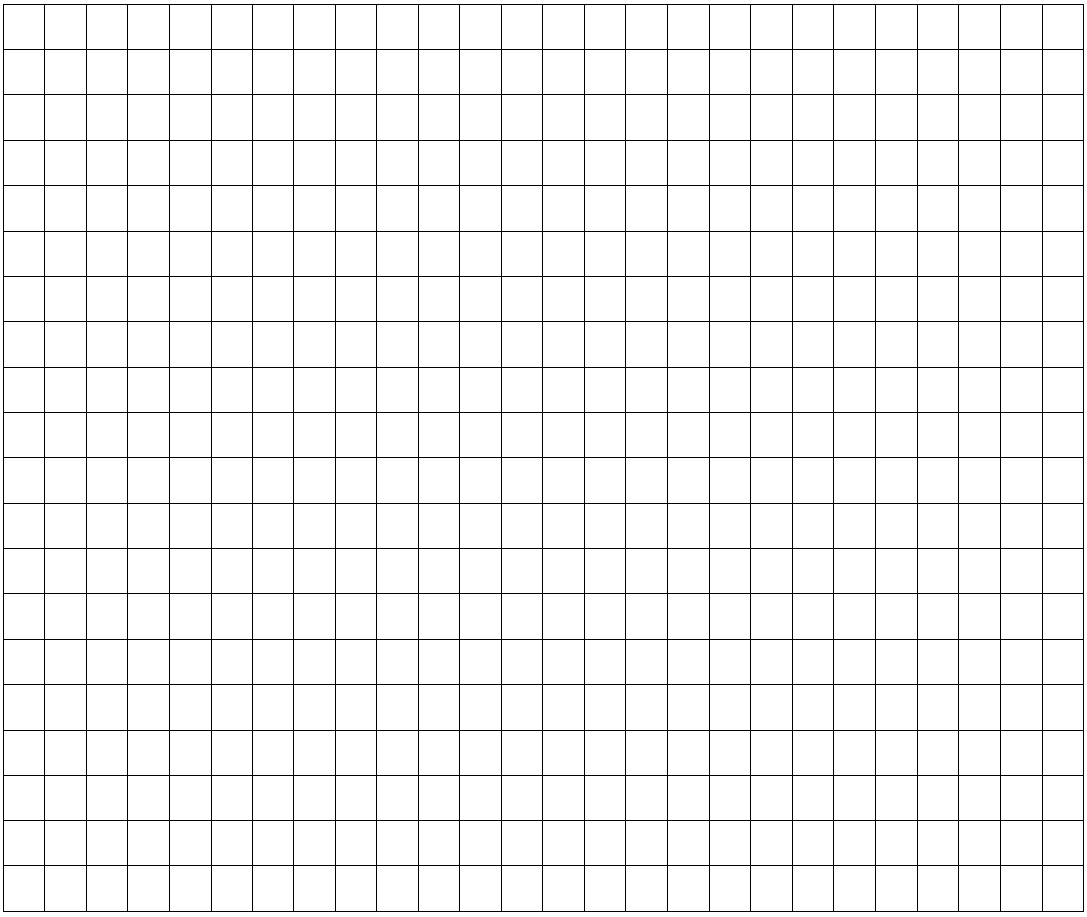
_____

In conducting the experiment, the student measured out 50 mL of 1 mol L^{-1} hydrochloric acid using a beaker, and poured this into a conical flask. She then placed the flask on a balance, together with an excess of zinc in a weighing boat. She recorded the mass, then added the zinc to the acid, and placed the weighing boat back on the balance. She then recorded the mass at intervals until it seemed the reaction had stopped. The student's results are displayed in the table below.

Time / s	0	10	20	30	40	50	60	70	80	90	100
Mass / g	90.00	89.89	89.80	89.70	89.62	89.56	89.52	89.50	89.50	89.50	89.50
Total mass lost / g	0							0.50	0.50	0.50	0.50

(f) Complete the table by filling in the missing data. (1 mark)

(g) Graph the data on the graph paper below, labeling your line '1M HCℓ'. (4 marks)



Question 37 (continued)

(h) Other than by repeating the experiment, state one way in which the student might have modified her method to obtain more accurate results. (1 mark)

_____

_____

(i) With reference to collision theory, explain the shape of the graph between 30 seconds and 70 seconds. (3 marks)

_____

_____

_____

_____

_____

The experiment was repeated using 50 mL of 0.5 mol L^{-1} hydrochloric acid.

(j) On the same graph used in part (g), **sketch** the results you would expect using 50 mL of 0.5 mol L^{-1} hydrochloric acid. Label this line '0.5M HCℓ'. (2 marks)

(k) State **one** factor that was important for the student to **control** in order to obtain valid results. (1 mark)

_____

Question 38 **(13 marks)**

Year 11 Chemistry students were given the task of identifying three white powders, sodium carbonate, sodium chloride and sodium nitrate.

A 2.00 g sample of each white powder was completely dissolved in 100 mL distilled water and tests carried out on separate 20.0 mL samples.

Give two **chemical tests** and **observations** that could be used to identify the powders.

The first test should enable the students to identify one of the three powders.
The second test should enable the students to identify one of the remaining two powders; it is necessary to clearly state which powder is being tested to gain full marks. (7 marks)

Test 1	Observations Sodium Carbonate Sodium chloride Sodium Nitrate
Test 2	Observations (remaining two powders) Powder 1 (Name:_____) Powder 2 (Name:_____)

b) Calculate the number of moles of sodium carbonate in the 20.0 mL sample. (2 marks)

c) Calculate the concentration of the sodium carbonate in the 100 mL sample. (1 mark)

Sodium chloride solution can be made by reacting sodium hydroxide and hydrochloric acid.

d) Calculate the minimum volume of 2.00 mol L^{-1} hydrochloric acid required to produce 2.00 g of sodium chloride. (3 marks)

Question 39 **(10 marks)**

As the human race seeks to reduce its reliance on fossil fuels, the importance of discovering alternative fuels, and new ways of producing fuels, becomes ever more important. Methanol (CH_3OH) is one such alternative fuel, and plays a number of important roles in replacing fossil fuels: it can be mixed with petrol; it can be converted into diesel; and it can be used in the production of biodiesel.

Methanol can be made from carbon monoxide and hydrogen. Currently, the most commonly used method of producing the carbon monoxide and hydrogen is called steam reforming, and involves the reaction of methane (from natural gas) and steam according to the following equation:

$$2\ CH_4(g)\ +\ 3\ H_2O(g)\ \rightarrow\ CO(g)\ +\ CO_2(g)\ +\ 7H_2(g)$$

The carbon monoxide and hydrogen then react to produce methanol according to the following equation:

$$CO(g)\ +\ 2\ H_2(g)\ \rightarrow\ CH_3OH(g)$$

10 kg of carbon monoxide are mixed with 10,000 L of hydrogen gas at STP.

(a) Find the limiting reactant (using the second equation). (4 marks)

(b) What is the maximum mass of methanol that can be formed? (2 marks)

(c) How many moles of unreacted gas remain at the end of the reaction? (2 marks)

Although the heat produced by the reactions, described on the previous page, can be used to generate the electricity needed for the process, more sustainable methods of production are sought. A team of researchers at the University of Texas have developed a new method of producing methanol that involves using copper(II) oxide nanowires coated in copper(I) oxide and submerged in a solution containing carbon dioxide. When subjected to sunlight, the carbon dioxide is converted to methanol whilst avoiding the excess energy input.

(d) By considering the reactions outlined above, give two ways in which this new method of production may help the environment. (2 marks)

Question 40 **(12 marks)**

Although petrol is made up predominantly of alkanes with between seven and eleven carbon atoms, these are often combined with additives to improve performance.

An additive used to prevent knocking (an effect caused by uncontrolled combustion in the cylinders of a combustion engine) was analysed by burning it in excess oxygen and collecting the gases formed. The additive contained carbon, hydrogen and oxygen, and it was found that a 12.99 g sample of the anti-knocking additive produced 31.16 g of carbon dioxide and 6.37 g of water upon combustion.

(a) Find the empirical formula of the anti-knocking additive. Show clear working.

(7 marks)

Subsequent analysis of the anti-knocking additive involved taking another 9.69 g sample and heating it in the absence of oxygen to vaporise it. It was found that the vapours occupied 2.00 L at STP.

(b) Find the molecular formula of the anti-knocking additive. Show clear working.
(3 marks)

(c) The melting point of the additive is 78 °C. Comment on this value, with reference to any intermolecular forces that may be present in the solid. (2 marks)

Bonus question: What colour is the All Blacks rugby jumper? _____

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Spare answer page

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