Semester Two Examination
Question/Answer Booklet

ATAR CHEMISTRY
Units 1 and 2
Semester 2 2015

Name: _____

Teacher : _____

Time allowed for this paper
Reading time before commencing work: ten minutes
Working time for paper: two hours and thirty minutes

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/tape, ruler, and highlighters

Special items: non-programmable calculators satisfying the conditions set out by the SCSA 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.

Section 1	Section 2	Section 3	Total	Percentage
/50	/60	/40	/150	%

Structure of this paper

Section	Number of questions	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	45	50	33
Section Two: Short answer	9	60	60	40
Section Three: Extended answer	3	45	40	27
		TOTAL	**150**	**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 place a cross in the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, indicate your choice clearly. 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.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

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.

Section One: Multiple-choice **33% (50 marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, place a cross in the box to indicate your answer. If you make a mistake, indicate your choice clearly. 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: 45 minutes.

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1. The subatomic particle arrangement of five different species is shown below. Which of the following are **correct**?

	Species	Protons	Neutrons	Electron configuration
(i)	^{36}Cl	17	19	2,8,7
(ii)	$^{27}Al^{3+}$	13	14	2,8,3
(iii)	^{10}Be	4	6	2,2
(iv)	$^{16}O^{2-}$	8	8	2,8
(v)	^{14}N	7	7	2,7

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

2. Which of the following correctly identifies both a pure substance and a mixture?

	Pure substance	**Mixture**
a.	salt water	air
b.	ethanol	water
c.	methane	stainless steel
d.	sulfurous acid	ammonia

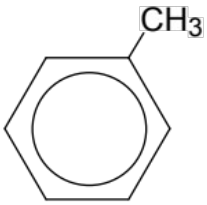
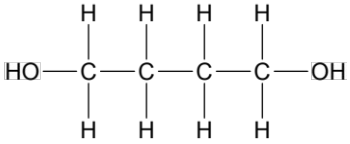
3. Consider the two sulfur-containing compounds below.

Potassium persulfate	Guanidinium thiocyanate
$K_2S_2O_8$	$C_2H_6N_4S$

Which of these compounds contains the **highest** percentage of sulfur by mass and what is this value?

a. Potassium persulfate, 33.4%
b. Guanidinium thiocyanate, 27.1%
c. Potassium persulfate, 23.7%
d. Guanidinium thiocyanate, 28.6%

4. Consider the information given in the following table.

	Toluene	Butane-1,4-diol
Structural diagram		
Molar mass, M (g mol^{-1})	92.134	90.12
Vapour pressure at 50 ˚C (kPa)	12.28	0.014

Which is the **best** explanation for the difference in vapour pressure of these two compounds?

a. Toluene has a higher molar mass than butane-1,4-diol
b. Butane-1,4-diol has fewer carbon atoms in its structure than toluene
c. Toluene has stronger dispersion forces than butane-1,4,-diol
d. Butane-1,4-diol has stronger intermolecular forces than toluene

5. Which of the following would have dispersion forces as the **only** intermolecular force present in a pure sample?

a. SO_2
b. CS_2
c. CH_2Cl_2
d. CO

6. Which of these gives the correct shape for each of the covalent molecules?

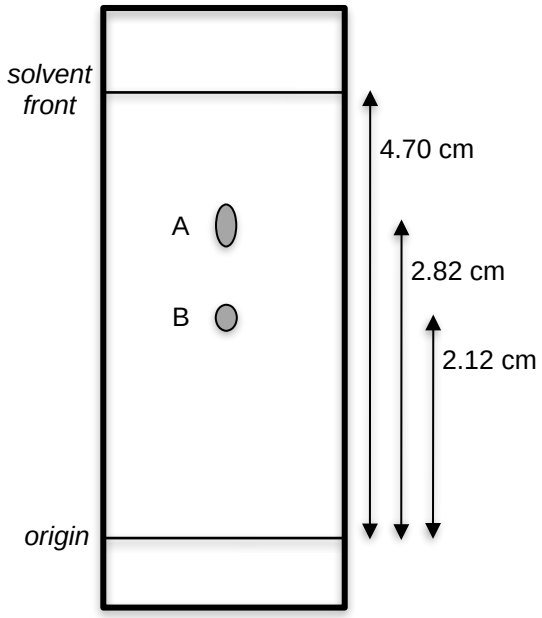
	SO_3	**HCN**	**F_2O**
a.	pyramidal	linear	bent / v-shaped
b.	trigonal planar	linear	bent / v-shaped
c.	trigonal planar	bent / v-shaped	linear
d.	pyramidal	trigonal planar	linear

7. In which of the following are the covalent bonds ranked in order of decreasing polarity (i.e. most polar to least polar)?

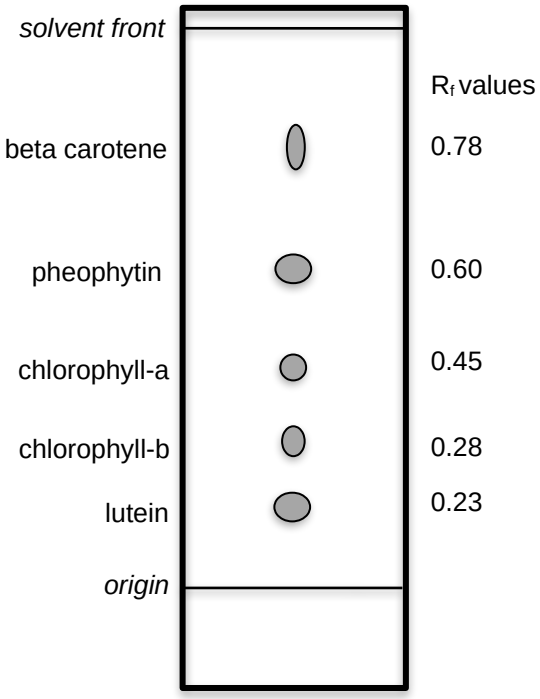
a. H-O > H-F > H-Br > H-C
b. H-C > H-Br > H-O > H-F
c. H-F > H-C > H-O > H-Br
d. H-F > H-O > H-Br > H-C

8. A group of students were analysing the pigments in a plant leaf sample by thin layer chromatography (TLC). A diagram of their TLC plate is shown (below, left) as well as a standard TLC plate produced from the analysis of the pigments in spinach leaves (below, right).

Unknown sample



Standard – spinach leaves



The students calculated the retention factor, R_f, for the unidentified pigments A and B using the following formula;

$$R_f = \frac{\text{distance travelled by solute component}}{\text{distance travelled by solvent}}$$

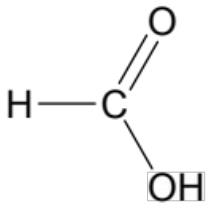
Use the TLC data provided to determine the R_f value for pigment A and compare this to the standard TLC plate to identify A. You may assume the plates were run under identical conditions.

a. R_f value = 0.6 — A is pheophytin
b. R_f value = 0.45 — A is chlorophyll-a
c. R_f value = 0.78 — A is beta carotene
d. R_f value = 1.7 — A is beta carotene

9. A small sample of sodium carbonate solution is mixed with hydrochloric acid. Which of the following correctly shows the balanced ionic equation for the reaction that would take place?

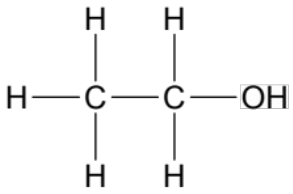
a. $Na_2CO_3(aq) + 2\ H^+(aq) \rightarrow 2\ Na^+(aq) + CO_2(g) + H_2O(l)$
b. $CO_3^{2-}(aq) + 2\ H^+(aq) \rightarrow CO_2(g) + H_2O(l)$
c. $Na_2CO_3 + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + CO_2(g) + H_2O(l)$
d. $CO_3^{2-}(aq) + 2\ H^+(aq) \rightarrow H_2CO_3(aq)$

10. Formic acid (methanoic acid) is used as a preservative and antibacterial agent, as well as in various cleaning products. It has a boiling point of 101 ˚C and its structure is shown to the right.

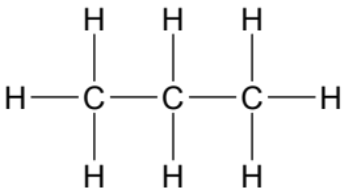


Which of the following substances would be **least** soluble in formic acid?

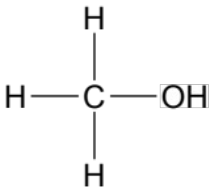
a.



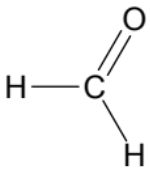
b.



c.



d.



Questions 11 and 12 relate to the following experiment.

A chemistry class was given the task of distinguishing between two white powders, sodium hydroxide (NaOH) and sodium sulfate (Na_2SO_4). The students began by dissolving each of the powders into separate beakers of water.

11. Which of the solutions below would **not** be useful in distinguishing between the NaOH and Na_2SO_4 solutions, when a small amount was added to each?

    a. $Zn(NO_3)_2(aq)$
    b. $BaCl_2(aq)$
    c. $Pb(NO_3)_2(aq)$
    d. $MgCl_2(aq)$

12. The students suggested a flame test be conducted to distinguish the two aqueous solutions but their teacher said this would not work. What is the main reason a flame test would not help the students?

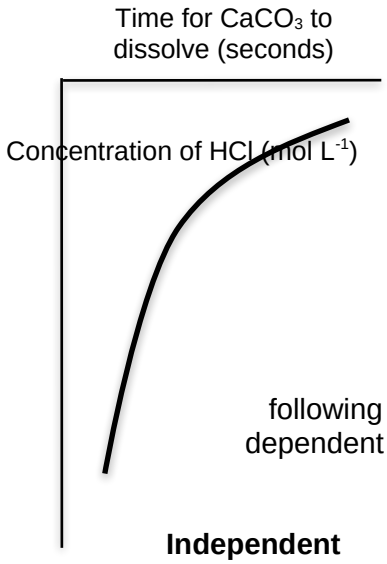
    a. Flame tests cannot be done on aqueous solutions
    b. Both these ionic compounds have the same cation
    c. Only transition metals can be distinguished by flame tests
    d. Flame tests are unreliable

Questions 13 and 14 relate to the following experiment.

A group of chemistry students set up an experiment to investigate reaction rate. They had 5 beakers, each containing the same mass of calcium carbonate powder. To each beaker they added 50.0 mL of hydrochloric acid. The concentration of the hydrochloric acid in each beaker was 0.25 mol L^{-1}, 0.5 mol L^{1-}, 0.75 mol L^{-1}, 1.0 mol L^{-1} and 1.25 mol L^{-1} respectively. In each case they measured how long it took, in seconds, for the calcium carbonate powder to dissolve completely.

The equation for the reaction that took place in each beaker is shown below, along with a graph summarising their data.

$$2\ HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$



13. Which of the following correctly states the independent variable, dependent variable and a controlled variable in this experiment?

	Controlled	Independent	Dependent
a.	time for $CaCO_3$ to dissolve	concentration of HCl	mass of $CaCO_3$
b.	concentration of HCl	time for $CaCO_3$ to dissolve	volume of HCl
c.	time for $CaCO_3$ to dissolve	volume of HCl	temperature of room
d.	concentration of HCl	mass of $CaCO_3$	volume of HCl

14. Looking at the students' graph, what trend can be identified from the data collected in this experiment?

    a. With an increase in HCl concentration, the $CaCO_3$ takes longer to dissolve
    b. With an increase in HCl concentration, there are more collisions occurring between the reactant particles
    c. With an increase in HCl concentration, less $CaCO_3$ is consumed
    d. With an increase in HCl concentration, there is an increased rate of reaction

15. If the volume of a constant mass of gas is halved at constant temperature, which of the following are **true**?

    (i) the pressure of the gas would increase
    (ii) the average kinetic energy of the gas would increase
    (iii) the number of collisions between the gas particles would increase

    a. (i) only
    b. (i) and (iii) only
    c. (iii) only

d. (i), (ii) and (iii)

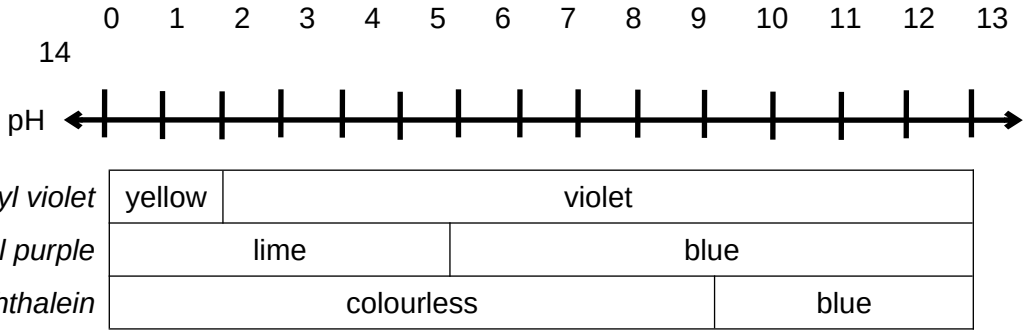
16. Which of the following statements are **true** regarding enzymes?

(i) Enzymes are catalysts
(ii) Enzymes lower the ΔH of a reaction
(iii) Enzymes increase the rate of reaction
(iv) Enzymes increase the proportion of successful collisions
(v) Enzymes increase the kinetic energy of particles

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

Questions 17 and 18 relate to the following information.

The following diagram shows the colour of three indicators for varying pH values.



17. What colour would you expect a 1.0 mol L^{-1} solution of potassium hydroxide (KOH) to turn if a few drops of each of these indicators was added to different samples of potassium hydroxide solution?

	Methyl violet	**Bromocresol purple**	**Thymolphthalein**
a.	violet	blue	blue
b.	blue	violet	colourless
c.	yellow	blue	colourless
d.	blue	violet	blue

18. A mystery solution was tested with each of the above indicators and the results are shown below.

Indicator	**Colour**
Methyl violet	violet
Bromocresol purple	lime
Thymolphthalein	colourless

What is the narrowest pH range you could assign to this substance based on this data?

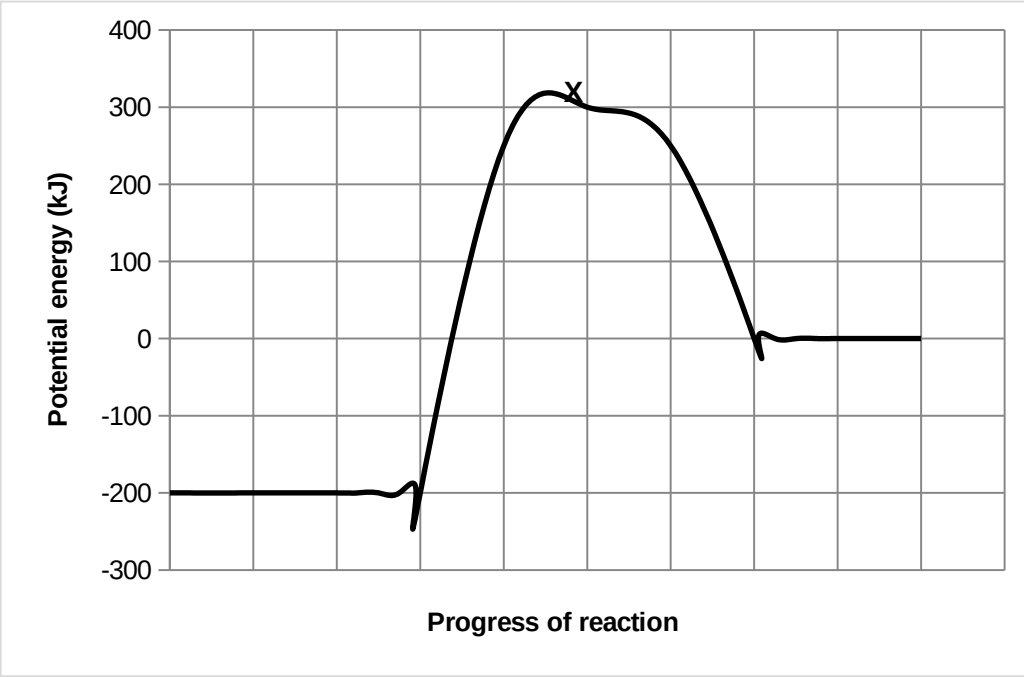
a. Below 10
b. Between 2 and 6

c. Below 6
d. Between 2 and 10

19. A 99.0 g sample of cobalt(II) chloride was added to 150 mL of water at 20 ˚C and the solution was stirred until no more solute would dissolve. Some of the $CoCl_2$ remained undissolved at the bottom of the beaker. The solution was then heated from 20 ˚C to 40 ˚C while stirring. If the solubility of cobalt(II) chloride at 40 ˚C is 69.5 g per 100 mL of water, what observation would have been noted as the solution reached its final temperature?

a. No change would be observed
b. More solute crystals would appear
c. Some solute crystals would dissolve
d. All solute crystals would dissolve

Question 20 and 21 relate to the following energy profile diagram.



20. What are the values for the heat of enthalpy (ΔH) and the activation energy (E_a) for this reaction?

	ΔH (kJ)	**E_a (kJ)**
a.	-200	+300
b.	+200	+500
c.	-200	+500
d.	+200	+100

21. Which of the following is **not** correct regarding X?
a. X represents the transition state
b. Particles at X have the highest enthalpy
c. X only exists temporarily
d. All particles at X will quickly form products

22. Which of the following best describes what is occurring when a liquid boils?

a. Evaporation is occurring at the surface of the liquid.
b. The vapour pressure of the liquid is equal to the atmospheric pressure.
c. The temperature of the liquid is equal to the temperature of the surroundings.
d. Bubbles are forming near the source of heat.

23. Consider the following organic compounds:

(i) ethane
(ii) ethene
(iii) benzene
(iv) dibromoethene

The compounds which would most readily undergo addition reactions are:

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

24. In which of the following processes is water acting as a BASE?

a. $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$
b. $HS^- + H_2O \leftrightarrow S^{2-} + H_3O^+$
c. $CH_3COO^- + H_2O \leftrightarrow CH_3COOH + OH^-$
d. $NH_2^- + H_2O \leftrightarrow NH_3 + OH^-$

25. Which of the following statements regarding sulfuric acid are correct?

(i) It is a strong acid
(ii) It is a diprotic acid
(iii) It has a pH greater than 7
(iv) It would form a white precipitate when added to a solution of barium nitrate

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

End of Section One

Section Two: Short answer **40% (60 marks)**

This section has **9** questions. Answer **all** questions. Write your answers in the spaces provided.

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

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: 60 minutes.

Question 26 **(9 marks)**

Write **ionic** equations for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'. In each case **describe in full what you would observe**, including any colours, odours, precipitates (give the colour) and gases evolved (give the colour or describe as colourless).

a) Bromine gas is introduced to a container of propane gas in the presence of ultraviolet light (3 marks)

Equation _____

Observation _____

_____

b) A solution of phosphoric acid is added to barium hydroxide solution. (3 marks)

Equation _____

Observation _____

_____

c) Ammonium acetate solution is added to sodium hydroxide solution. (3 marks)

Equation _____

Observation _____

Question 27 **(5 marks)**

Given the reaction for the oxidation of sucrose:

$$C_{12}H_{22}O_{11}\,(aq) + 12\,O_2\,(g) \rightarrow 12\,CO_2\,(g) + 11\,H_2O\,(l) \qquad \Delta H = -5649\ kJ/mol$$

a) How much energy is released during the reaction of 17.1 g of sucrose?

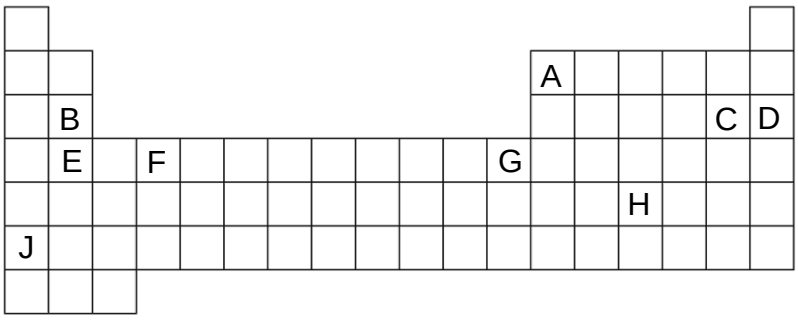
(2 marks)

b) What volume of oxygen, measured at STP, is consumed when 28.25 kJ of energy is produced via the reaction of sucrose?

(3 marks)

Question 28 **(6 marks)**

Consider the elements labelled A-J on the periodic table below.



(a) Which two (2) elements are likely to have the most similar properties? (1 mark)

_____

(b) An atom was found to have 20 protons, 22 neutrons and 20 electrons. Which of the above elements would have the same chemical properties as this atom? Explain. (2 marks)

_____

_____

(c) Which element above would have the; (3 marks)

(i) highest ionisation energy? _____

(ii) largest atomic radius? _____

(iii) highest electronegativity? _____

Question 29 **(12 marks)**

Consider the solubility information given in the table below.

	Solubility in water (g per 100 mL)
Potassium nitrate (KNO_3)	32
Ammonium nitrate (NH_4NO_3)	150
Potassium phosphate (K_3PO_4)	90

(a) Classify the solutions below as 'saturated', 'unsaturated' or 'supersaturated'. Explain your reasoning and show your working. (5 marks)

(i) 216 g of K_3PO_4 was dissolved in 240.0 mL of water.

_____

_____

_____

(ii) 0.375 mol of KNO_3 was dissolved in 170.0 mL of water.

_____

_____

_____

(b) A saturated solution of NH_4NO_3 was prepared. Describe how this could be used to form a supersaturated solution. (2 marks)

_____

_____

_____

_____

_____

_____

The two solutions described in part (a) were mixed together.

(c) Calculate the final concentration (in mol L^{-1}) of potassium ions (K^+) in the resulting solution. (5 marks)

Question 30 **(4 marks)**

Identify by name or formula an example of each of the following.

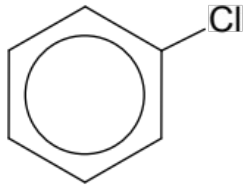
Description	Name or formula
A saturated hydrocarbon	
A soluble, green solid	
A metal ion that generally forms insoluble ionic compounds	
An electrically conducting, covalent network solid	

Question 31 **(7 marks)**

Organic compounds can undergo many different types of reactions.

(a) Complete the reaction below by adding the inorganic reactant and drawing the structural diagram for the organic product formed. (2 marks)

Diagram:



Name: chlorobenzene

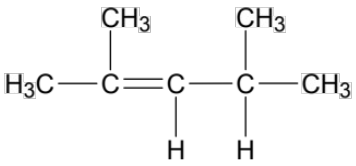
\+ ☐ $\xrightarrow{AlCl_3}$

Diagram:

Name: 1,4-dichlorobenzene

(b) Complete the reaction below by giving the IUPAC name for the organic reactant and the structural diagram and IUPAC name for the organic product formed. (3 marks)

Diagram:



Name:

\+ **Br_2** $\longrightarrow$

Diagram:

Name:

(c) Name the type of reaction occurring in; (2 marks)

(a) _____

(b) _____

Question 32 **(6 marks)**

Most modern cars are powered by an engine with a 4-stroke combustion cycle. The purpose of each stroke is described below.

1. Intake stroke - the fuel is injected in as a fine mist, where it mixes with air
2. Compression stroke - the fuel/air mixture is compressed into a small volume
3. Combustion stroke - a spark plug ignites the fuel/air mixture, which explodes
4. Exhaust stroke - exhaust fumes leave through the valve

Explain, in terms of the collision theory, how each of the conditions described in **stroke 1, 2 and 3** affect the rate of reaction between the fuel and the air.

Question 33 **(5 marks)**

The equation below represents the reaction between solid iron (Fe) and hypochlorous acid (HClO).

$$6\ HClO(aq) + 6\ H^{+}(aq) + 2\ Fe(s) \rightarrow 3\ Cl_2(g) + 6\ H_2O(l) + 2\ Fe^{3+}(aq)$$

A piece of iron was placed in a solution of 1.53 mol L^{-1} hypochlorous acid. The reaction was allowed to go to completion and at the end all of the solid iron had reacted. If 1.48 L of Cl_2 was produced at STP:

(a) Calculate the volume of HClO that would have been required for the reaction to take place. (3 marks)

(b) Calculate the mass of iron that must have been present. (2 marks)

Question 34 **(6 marks)**

Using appropriate examples explain the difference between the following terms:

a) Ionisation and dissociation

_____

_____

_____

_____

(3 marks)

b) Strong acids and weak acids

_____

_____

_____

_____

(3 marks)

End of Section Two

Section Three: Extended answer **27% (40 marks)**

This section contains **three (3)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

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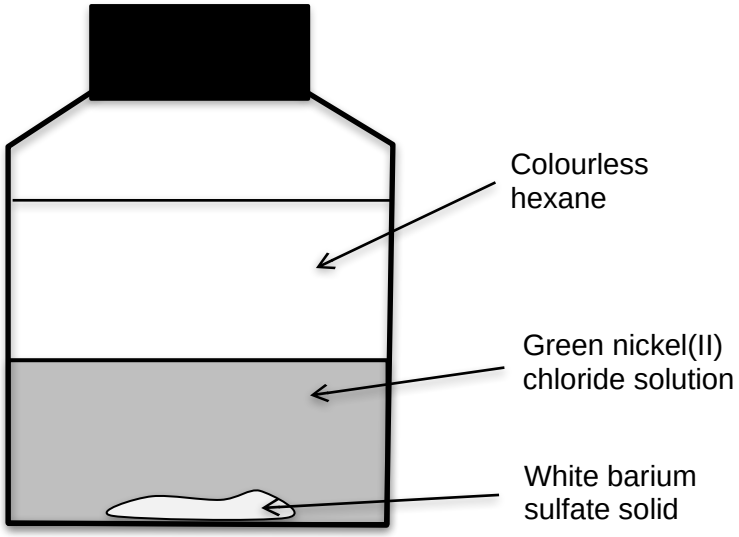
Suggested working time: 45 minutes.

Question 35 **(17 marks)**

A group of chemistry students were given the task of separating a mixture into its individual components. They were given a jar with four different compounds mixed together. The four components of the mixture were as follows;

- 50 mL of hexane
- 50 mL of water
- 0.5 g of nickel(II) chloride, and
- 0.5 g of barium sulfate.

A sketch of the appearance of the mixture is shown in the diagram below.



The students were also given several pieces of data regarding each compound in the mixture. This is given in the table below.

	Appearance at room temperature	**Boiling point (°C)**	**Density (g mL^{-1})**
Hexane	Colourless liquid	68	0.655
Water	Colourless liquid	100	1
Nickel(II) chloride	Green solid	973	-
Barium sulfate	White solid	1600	-

a. Draw the structural formula for three of the relevant compounds, representing all valence shell electron pairs either as : or – . (6 marks)

	Structural Formula / Lewis Structure / Electron Dot Diagram
Hexane (C_6H_{14})	
Nickel chloride ($NiCl_2$)	
Barium sulfate ($BaSO_4$)	

b. Explain why nickel(II) chloride is soluble in water, but hexane is not. (6 marks)

c. Explain how you could separate the mixture to produce pure samples of each of the four original compounds. (5 marks)

Question 36 **(15 marks)**

A chemist was preparing for his next experiment by organising and labelling all his bottles of solutions. He had five bottles to go when the fire alarm went off for a practice safety drill. When he got back to his bench later he found five bottles, each containing a clear colourless liquid. Next to these bottles were the remaining five labels;

Barium hydroxide $Ba(OH)_2$ 0.25 mol L^{-1}	Sodium chloride NaCl 0.25 mol L^{-1}	Ethanoic acid CH_3COOH 0.25 mol L^{-1}
Hydrochloric acid HCl 0.25 mol L^{-1}	Sodium hydroxide NaOH 0.25 mol L^{-1}	

He set about identifying each solution so that he could finish labelling them. He began by adding a few drops of sulfuric acid to a small sample of each. This test allowed him to identify the $Ba(OH)_2$ solution straight away.

(a) What observation would he have made to allow this identification? Write the ionic equation for the reaction that could have taken place in the test tube containing $Ba(OH)_2$. (3 marks)

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_____

He then added some powdered ammonium chloride (NH_4Cl) to a new sample of the remaining four unidentified solutions. Bubbles were observed to form with **one** of the unknown solutions and an unpleasant, pungent smelling gas was produced.

(b) Identify this solution and write the ionic equation for the reaction that was occurring. (3 marks)

_____

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_____

The gas produced by the reaction in part (b) was collected and dissolved in a sample of distilled water.

(c) Describe the expected observations if litmus indicator was added to the water sample once the gas had dissolved and write an equation that supports these observations. (3 marks)

_____

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_____

Universal indicator was then added to new samples of the remaining three unidentified solutions.

(d) Which substance would be identified in this step? (1 mark)

A piece of zinc metal was added to the final two solutions. In one solution, a fast reaction was seen, with much effervescence (bubbles). The other test tube also showed some effervescence but at a much slower rate.

(e) Explain in detail why a difference in reaction rate was observed between these two solutions and how this observation allowed the chemist to identify and distinguish these two solutions from one another. (5 marks)

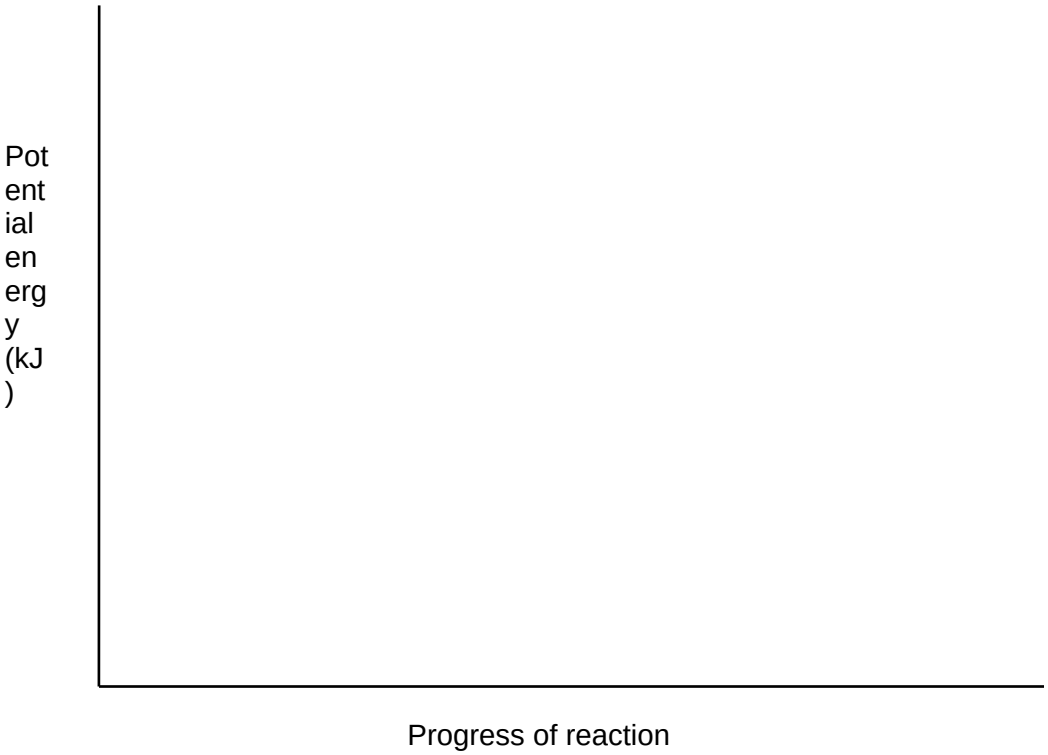
Question 37 **(8 marks)**

Bioethanol is the same compound as ethanol (C_2H_5OH) but refers to ethanol that has been produced from 'biomass', which is a renewable resource. Ethanol is a useful fuel and combusts according to the following equation;

$$C_2H_5OH\,(l) + 3\,O_2\,(g) \rightarrow 2\,CO_2\,(g) + 3\,H_2O\,(l) + 1367\ kJ$$

If the activation energy for the combustion reaction above is 387 kJ;

(a) Draw a fully labelled energy profile diagram, **to scale,** for the combustion of ethanol. (4 marks)



(b) Butane is another commonly used fuel that is used in lighters and portable stoves. The molar masses and boiling points of ethanol and butane can be found in the table below.

Substance	Molar mass (g mol^{-1})	Boiling point (°C)
Ethanol (C_2H_5OH)	46.068	78.4
Butane (C_4H_{10})	58.12	-1.0

Although butane is a heavier molecule and contains stronger dispersion forces, ethanol has a much higher boiling point. Using your knowledge of intermolecular forces, explain this observation. (4 marks)

End of exam

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