

ROSSMOYNE SENIOR HIGH SCHOOL

CHEMISTRY STAGE 3

2010 SEMESTER 2

Your marks	Marks available
	50
	80
	70
	200

Name: _____ Final mark _____%

Teacher: (circle your teacher's name)

MR SMITH

MR LUCARELLI

MR SANDER

MS SMITH

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	Suggested working time	Number of questions available	Number of questions to be attempted	Marks
ONE: Multiple-choice	50 minutes	25	25	50
TWO: Short response	70 minutes	13	13	80
THREE: Extended response	60 minutes	5	5	70
[Total marks]				200

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2010*. 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 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.

3. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise.
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 the question(s) that you are continuing to answer at the top of the page.

SECTION 1: 25 multiple choice questions (50 marks 25%)

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.

1. In which of the following lists do all the species have the same electron configuration?

- (a) Na^+ K^+ Rb^+
- (b) Cl^- Ar Ca^{2+}
- (c) Ne Ar Kr
- (d) Cl^- Br^- I^-

2. A sulfate ion (SO_4^{2-}) contains the isotopes S-33 and O-15.
How many electrons and neutrons does the ion possess?

	electrons	neutrons
(a)	46	48
(b)	93	96
(c)	50	45
(d)	48	50

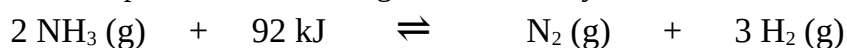
3. Which of the following elemental properties do not have an increasing trend across Period 3 of the Periodic Table?

- I. Atomic number
 - II. Atomic size
 - III. Electronegativity
 - IV. Ionization energy
 - V. Melting point
- (a) III and IV
 - (b) I, III and IV
 - (c) II and V
 - (d) I, II, IV and V

4. In which of the following solid substances is there only one type of bonding between the particles?

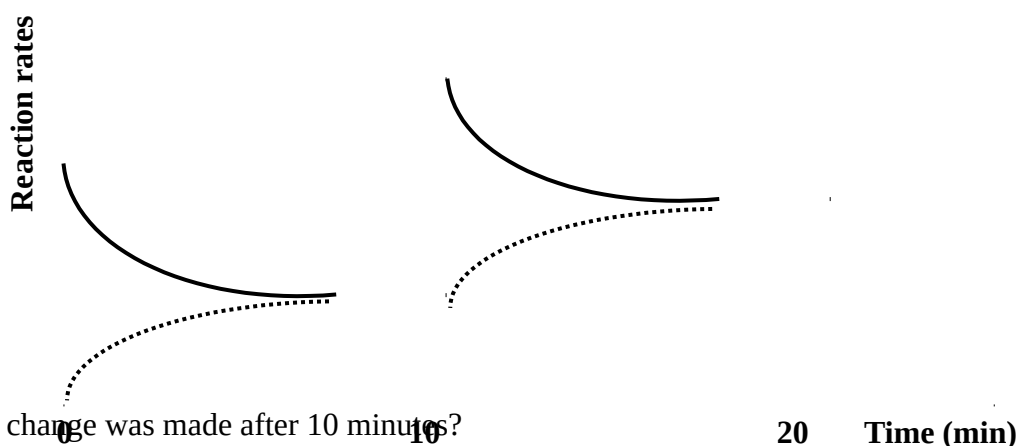
- (a) Aluminium hydroxide
- (b) Barium oxide
- (c) Calcium nitrate
- (d) Sodium nitrate

5. Some ammonia gas is pumped into a sealed container whose volume can be increased or decreased. The reversible decomposition reaction begins immediately.



The **forward** and **reverse** reaction **rates** are measured and after 10 minutes a change is made to the gas system. The reaction rates are measured for a further 10 minutes.

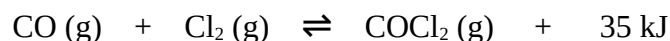
The following graph shows how the forward and reverse reaction rate changed during the 20 minutes.



What change was made after 10 minutes?

- (a) The volume of the gas mixture was decreased.
 - (b) More ammonia was pumped in.
 - (c) The mixture was heated.
 - (d) Some hydrogen was pumped in.
6. Adding a catalyst to an equilibrium system increases
- (a) the proportion of particles that have sufficient energy to react.
 - (b) the proportion of products present.
 - (c) the average kinetic energy of particles.
 - (d) the forward reaction rate more than the reverse reaction rate.

7. Carbon monoxide and chlorine react to form phosgene (COCl_2). The reaction is reversible.



Which of the following conditions will **increase** the **rate** of formation of phosgene?

- I. Increasing the temperature
- I. Increasing the pressure
- II. Removal of phosgene
- III. Decreasing the temperature
- IV. Decreasing the pressure

- (a) I and II
- (b) I, II and III
- (c) III, IV and V
- (d) IV and V

8. When carbon dioxide is bubbled through a suspension of lead carbonate some of the lead carbonate dissolves forming soluble lead hydrogencarbonate. The following equilibrium is established.



The correct equilibrium expression for this system is

- (a)
$$\frac{[\text{Pb(HCO}_3)_2]}{[\text{PbCO}_3] [\text{H}_2\text{O}] [\text{CO}_2]}$$
- (b)
$$\frac{[\text{PbCO}_3] [\text{H}_2\text{O}] [\text{CO}_2]}{[\text{Pb(HCO}_3)_2]}$$
- (c)
$$\frac{[\text{Pb(HCO}_3)_2]}{[\text{H}_2\text{O}] [\text{CO}_2]}$$
- (d)
$$\frac{[\text{Pb(HCO}_3)_2]}{[\text{CO}_2]}$$

9. In which of the following is the first species (in bold) acting as a base?

- (a) HCO_3^- + $\text{NH}_3 \rightleftharpoons \text{CO}_3^{2-}$ + NH_4^+
- (b) H_2PO_4^- + $\text{HCO}_3^- \rightleftharpoons \text{HPO}_4^{2-}$ + H_2CO_3
- (c) HPO_4^{2-} + $\text{NH}_4^+ \rightleftharpoons \text{H}_2\text{PO}_4^-$ + NH_3
- (d) SO_4^{2-} + $\text{Ba}^{2+} \rightleftharpoons \text{BaSO}_4$

10. Which of the following 0.1 mol L⁻¹ solutions has the lowest pH?

- (a) sodium sulfate Na_2SO_4
- (b) ammonium acetate $\text{NH}_4\text{CH}_3\text{COO}$
- (c) ammonium chloride NH_4Cl
- (d) sodium nitrate NaNO_3

11. An acid-base titration is performed to determine the concentration of a sodium hydroxide solution. The flask contains the solution of sodium hydroxide. Standardised ethanoic (acetic) acid is delivered from the burette. A student incorrectly uses the indicator bromophenol blue, which changes colour at about pH 4. Because of this incorrect choice

- (a) too much acid will be delivered and the calculated sodium hydroxide concentration will be too high
- (b) too much acid will be delivered and the calculated sodium hydroxide concentration will be too low
- (c) not enough acid will be delivered and the calculated sodium hydroxide concentration will be too high
- (d) not enough acid will be delivered and the calculated sodium hydroxide concentration will be too low

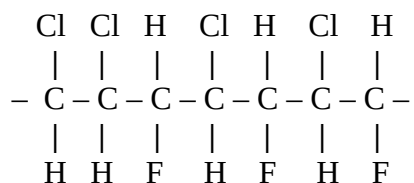
12. Which of the following ions is least likely to act as a base in aqueous solution?

- (a) CO_3^{2-}
- (b) HPO_4^{2-}
- (c) CH_3COO^-
- (d) HSO_4^-

13. A buffer solution is one that does not have its pH changed significantly when a small amount of acid or base is added. Which of the following solutions (where each substance has a concentration of 1 mol L^{-1}) would best act as a buffer?
- A solution of CH_3COOH and HCl
 - A solution of NaH_2PO_4 and Na_2HPO_4
 - A solution of CH_3COOH and H_3PO_4
 - A solution of NaOH and NH_3
14. In which of the following species is the oxidation state of sulfur the lowest?
- SO_3
 - SO_3^{2-}
 - $\text{S}_2\text{O}_4^{2-}$
 - $\text{S}_2\text{O}_6^{2-}$
15. Iodide ion (I^-) can be oxidized by X but not by Y. The identities of X and Y, respectively, could be
- | X | | Y |
|--------------------------------|-----|-------------|
| (a) bromine | and | chlorine |
| (b) gold (III) ions | and | silver ions |
| (c) acidified MnO_4^- | and | nitric acid |
| (d) iron (III) ions | and | nickel ions |
16. A student designs an electrochemical cell. One half cell consists of a nickel rod in a 1 mol L^{-1} nickel (II) sulfate solution. As the cell operates he notices that the green colour of this half cell becomes darker green. Which of the following could correctly describe the other half cell?
- Chromium rod in a chromium (III) chloride solution
 - Copper rod in a copper (II) sulfate solution
 - Lead rod in a lead nitrate solution
 - Zinc rod in a zinc chloride solution
- I and II
 - II and III
 - III and IV
 - I and IV

17. In an electrochemical cell
- (a) there is a flow of electrons.
 - (b) there is a flow of ions.
 - (c) oxidation and reduction occur at the same time.
 - (d) all of the above are occurring.
18. A colourless organic liquid (X) is reacted with an acidified potassium permanganate solution. The product is a liquid (Y). The liquid (X) and liquid (Y) are then reacted to produce a liquid (Z).
Which of the following general formulas represents the liquid (Y)?
[R represents the rest of the molecule.]
- (a) RCH_2OH
 - (b) RCOR
 - (c) RCOOR
 - (d) RCOOH
19. Chlorine gas reacts with hydrocarbons by both addition to multiple bonds and substitution of hydrogen atoms. Excess chlorine gas is mixed with 1 mole of each of the following. Which one will react with the most chlorine?
- (a) ethane
 - (b) ethene
 - (c) dichloroethane
 - (d) dichloroethene
20. How many of the following compounds can exhibit geometric (cis-trans) isomerism?
- 1,1-dibromopropene
 - 1,2-dibromopropene
 - 2,3-dibromopropene
 - 3,3-dibromopropene
- (a) 1
 - (b) 2
 - (c) 3
 - (d) 4

21. Choose the **false** statement regarding **alpha amino acids**
- (a) in solution they exist as ions.
 - (b) they always have an amino group ($-\text{NH}_2$) at one end of the molecule and a carboxyl group ($-\text{COOH}$) at the other end of the molecule.
 - (c) are important in protein synthesis.
 - (d) can form hydrogen bonds between their molecules.
22. One mole of an organic compound was burned in six moles of oxygen, producing only four moles of carbon dioxide and five moles of water. Which of the following formulas represents the organic compound?
- (a) $\text{CH}_3\text{CH}_2\text{COCH}_3$
 - (b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
 - (c) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
 - (d) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
23. Part of a polymer chains is represented by



Which of the following could be the monomer from which the polymer was made?

- I. cis-1-chloro-2-fluoroethene
 - I. trans-1-chloro-2-fluoroethene
 - II. 1-chloro-2-fluoroethane
- (a) I only
 - (b) II only
 - (c) I or II
 - (d) I or II or III

24. An industrial cooking oven has a thick layer of animal fat and oil sticking to the inside walls. Which of the following substances could be used to remove this layer?

I.	sodium stearate	$\text{CH}_3(\text{CH}_2)_{16}\text{COONa}$
II.	Calcium stearate	$(\text{CH}_3(\text{CH}_2)_{16}\text{COO})_2\text{Ca}$
III.	Sodium hydroxide	NaOH
IV.	Stearic acid	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$

- (a) I or II
- (b) III or IV
- (c) I or III
- (d) II or IV
25. Three of the following substances can be polymerized on their own by adding a starter catalyst. Which one will **not** polymerize?

- (a) $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$
- (b) $\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$
- (c) $\text{CH}_3\text{CH}_2\underset{\text{OH}}{\text{CH}}\text{CH}_2\text{COOH}$
- (d) $\text{HOOCCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$

SECTION 2 13 questions (80 marks 40%)

Answer ALL questions in Section 2 in the spaces provided below.

Suggested working time for this section is 70 minutes.

1. Write equations for the reaction that occurs in each of the following procedures.
If no reaction occurs, write 'no reaction'.

In each case describe what you would observe, including any

* colour change

* odour

* precipitate (give the colour)

* Gas evolutions (state the colour or describe as colourless)

If a reaction occurs but the change is not observable, you should state this.

- (a) Oxygen gas is bubbled through an acidified solution of iron (II) sulfate.

Equation (net ionic) _____

Observation _____

(3marks)

- (b) Ethene gas is bubbled through bromine water (aqueous solution of bromine).

Equation _____

Observation _____

(3marks)

2. For each of the following sets of observations:

(i) write a description of any **one** reaction that matches the observations, and

(ii) give an appropriate equation (net ionic) for **that** reaction.

e.g. A brown solution is added to a colourless solution, producing a brown precipitate.

Reaction *iron (III) nitrate solution is mixed with sodium hydroxide solution.*

Equation $Fe^{3+} + 3 OH^- \rightarrow Fe(OH)_3$

- a) A purple solution is mixed with a colourless solution, producing a colourless solution and a colourless gas

Reaction _____

Equation (net ionic) _____

(3 marks)

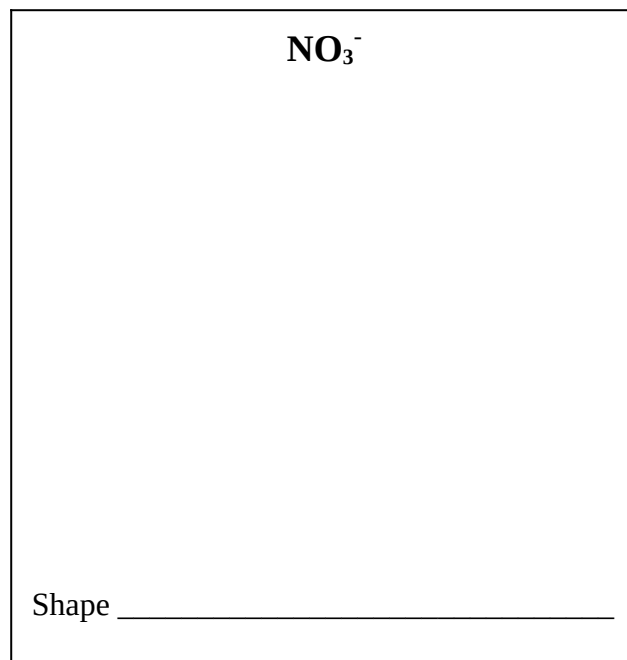
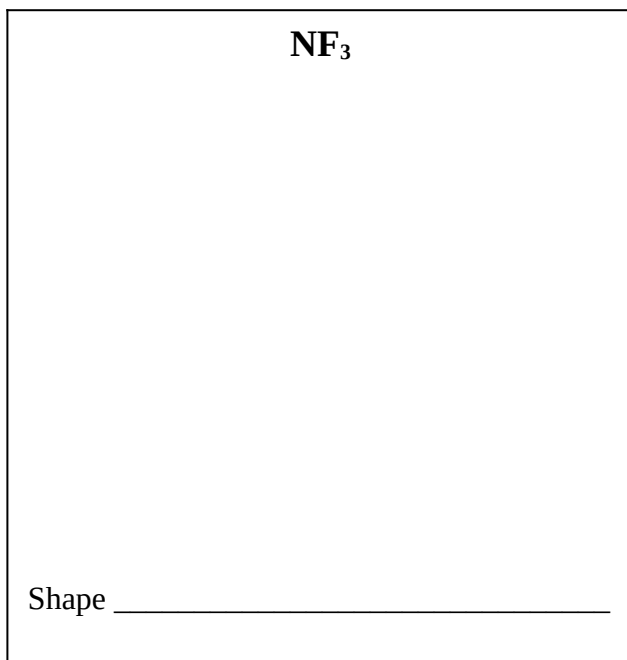
- b) A metal strip is placed in a green solution. Silvery-white crystals form on the strip and the green colour fades.

Reaction _____

Equation (net ionic) _____

(3 marks)

3. Draw electron-dot diagrams showing the arrangement of all valence electrons in the following chemical species.
Describe the shape of each (eg: linear/bent/etc)



(6 marks)

4. Methane reacts with fluorine to form four different fluorinated compounds.
Write the names and formulas of all the fluorinated methanes that are polar.

(4 marks)

5. The following table shows the solubility of two amines in water.

Amine	Methylamine CH_3NH_2	Dodecylamine $\text{CH}_3(\text{CH}_2)_{11}\text{NH}_2$
Solubility (g/100 mL)	108	0.05

Account for the solubility of these two amines in water. Include a labelled diagram.

(6 marks)

6. Three unlabelled beakers each contain the same volume of a 1 mol L^{-1} solution. The three solutions are:
- sodium hydrogensulfate (NaHSO_4)
 - sulfuric acid (H_2SO_4), and
 - phosphoric acid (H_3PO_4).

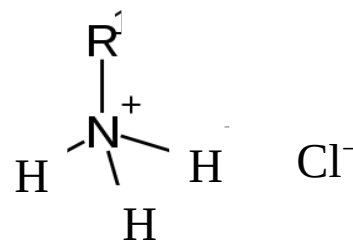
The student is asked to identify the solutions. He is also given a bottle of sodium hydroxide (NaOH) solution, a choice of indicators and is allowed to use any other item of laboratory glassware. The student was successful.

How did the student correctly identify the acids? Include equations to support your answer.

ENSURE YOUR ANSWER IS CLEAR AND WELL ORGANISED

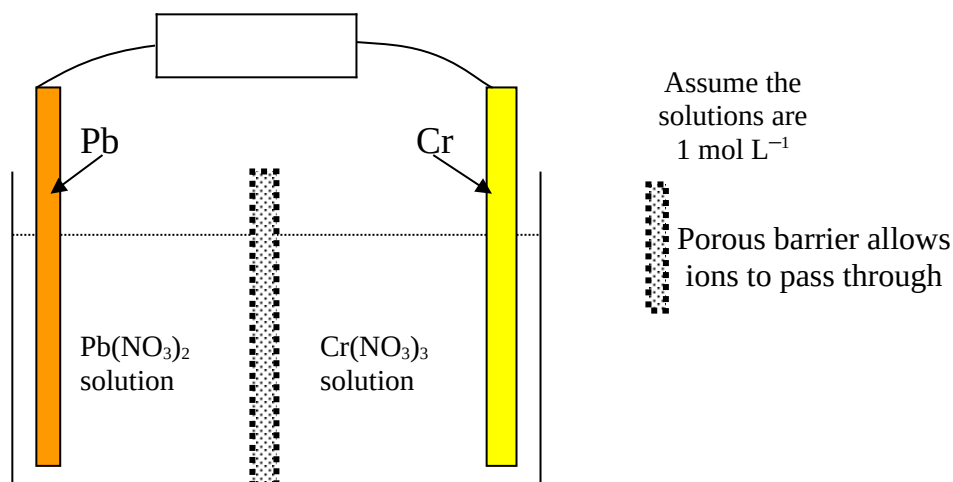
(7 marks)

7. Quaternary ammonium salts can be represented by the structural formula shown here. If the alkyl group (**R**) is long then the salt acts like a soap or detergent. If it is short the salt has no cleaning properties. Account for these properties of Quaternary ammonium salts. Include a labelled diagram.



(6 marks)

8. The electrochemical cell shown here contains two half cells separated by a porous membrane which allows ions to migrate through. Each half cell has a metal rod placed in a solution of its nitrate.



- (a) Write the two half reactions that occur, their standard reduction potentials and state whether each is oxidation, or reduction,

_____ $E^\circ =$ _____
 _____ $E^\circ =$ _____

(4 marks)

- (b) Write the equation for the redox reaction. (net ionic)

(2 mark)

- (c) What is the emf (electromotive force, or voltage) of the cell?

(1 mark)

- (d) Draw an arrow in the top box to show the direction of current (electron flow) in the wire connecting the two electrodes.

(1 mark)

- (e) What change (or changes) will be observed in the cell?

(3 marks)

9. A student is asked to identify four organic liquids, contained in four separate flasks.
- Octene
 - Hexan-3-ol (3-hexanol)
 - Hexan-3-one (3-hexanone)
 - Ethanoic acid

The student has access to any chemicals and glassware required.

Describe the tests that could be carried out, and the observations, that enable the liquids to be identified. Include equations as part of your answer.

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(8 marks)

10. The following table gives information about two substances. Use the information to determine whether each substance is acting as an **oxidising agent** (oxidant), or **reducing agent** (reductant) and provide a brief explanation to **justify** your answer.

Substance	Information	Oxidising agent or Reducing agent (remember to justify your answer)
Concentrated sulfuric acid H_2SO_4	Reacts with copper to produce sulfur dioxide.	
Hydrogen peroxide H_2O_2	Reacts with chlorine to produce chloride ion.	

(4 marks)

11. A student pours some silver nitrate solution into a bronze (copper-tin alloy) container. Is this wise? Explain why, or why not. Include an equation.

(3 marks)

13. Name, and draw structural diagrams for, the following organic compounds.

(9 marks)

SECTION 3**5 questions (70 marks 35%)**

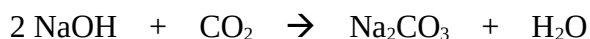
Extended answers

Answer ALL questions in Section 3 in the spaces provided.

Suggested working time for this section is 60 minutes.

1. Treatment of waste by-products in chemical industry 16 marks

In a chemical industries complex one production plant produces a waste caustic soda (NaOH) solution, which it stores in a large pond. Another production plant produces waste carbon dioxide. The chemical engineers decide to combine both wastes to produce the environmentally friendly by-product, sodium carbonate, by bubbling the carbon dioxide through the caustic soda solution.



The caustic soda pond contains 500 kL and has a hydroxide (OH^-) concentration of $1.00 \times 10^{-2} \text{ mol L}^{-1}$.

(a) What is the pH of the solution?

(2 marks)

(b) What is the mass of sodium hydroxide in the caustic soda pond?

(3 marks)

- (c) What mass of carbon dioxide is needed to completely react with the sodium hydroxide?
If you did not answer Part (b) above, use a mass of 100 kg sodium hydroxide

(4 marks)

- (d) The carbon dioxide is first cooled to 10°C and is pumped at a pressure of 200 kPa, delivering 150 L per minute. How long does it take to complete the reaction?

(5 marks)

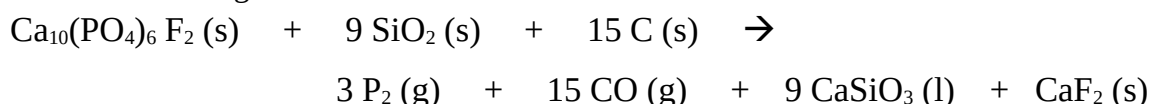
- (e) (i) The pond solution is still found to be alkaline (pH of about 9). Assuming all the carbon dioxide and sodium hydroxide have fully reacted, suggest why the pond solution is still alkaline.

(2 marks)

2. **Production of phosphorus from fluoroapatite****16 marks**

The mineral fluoroapatite [$\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$] is mixed with sand [SiO_2] and powdered carbon in a high temperature furnace. The phosphorus is produced as a gas [P_2], along with carbon monoxide. The reaction actually produces calcium oxide [CaO], which has a very high melting point. This would make the mixture difficult to control. So, as the calcium oxide is produced it reacts with the sand to form a low melting point slag, calcium silicate [CaSiO_3]. This liquid slag is easily separated from the furnace.

The reaction occurring is:



- (a) Give a reason why this reaction is carried out in a high temperature furnace.

(2 marks)

- (b) The main reaction can be represented by the two half reactions:

- phosphate ion producing phosphorus (P_2) and oxide ions (O^{2-}), and
- carbon reacting with oxide ion producing carbon monoxide

Which element, phosphorus or carbon, is being oxidised? _____

Justify your answer by referring to oxidation numbers.

- (c) List three elements whose oxidation states are not changing.

(6 marks)

- (d) Some of the oxide ions produced in Part (b) becomes part of the liquid slag by reacting with calcium ions and sand.

Write the equation for the formation of the slag.

(2 marks)

[illegible]

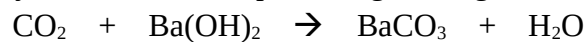
(6 marks)

3. **Analysing an organic compound****13 marks**

A certain organic compound is known to contain only carbon, hydrogen and oxygen.

The compound was analysed as follows.

- A 2.149 g sample was burned and the carbon dioxide produced was bubbled through a barium hydroxide solution, producing 11.27 g of barium carbonate (BaCO_3).



- The mass of water produced by burning of the sample was 0.7721 g
- The compound was found to have a molar mass of 150.1 g mol^{-1} .

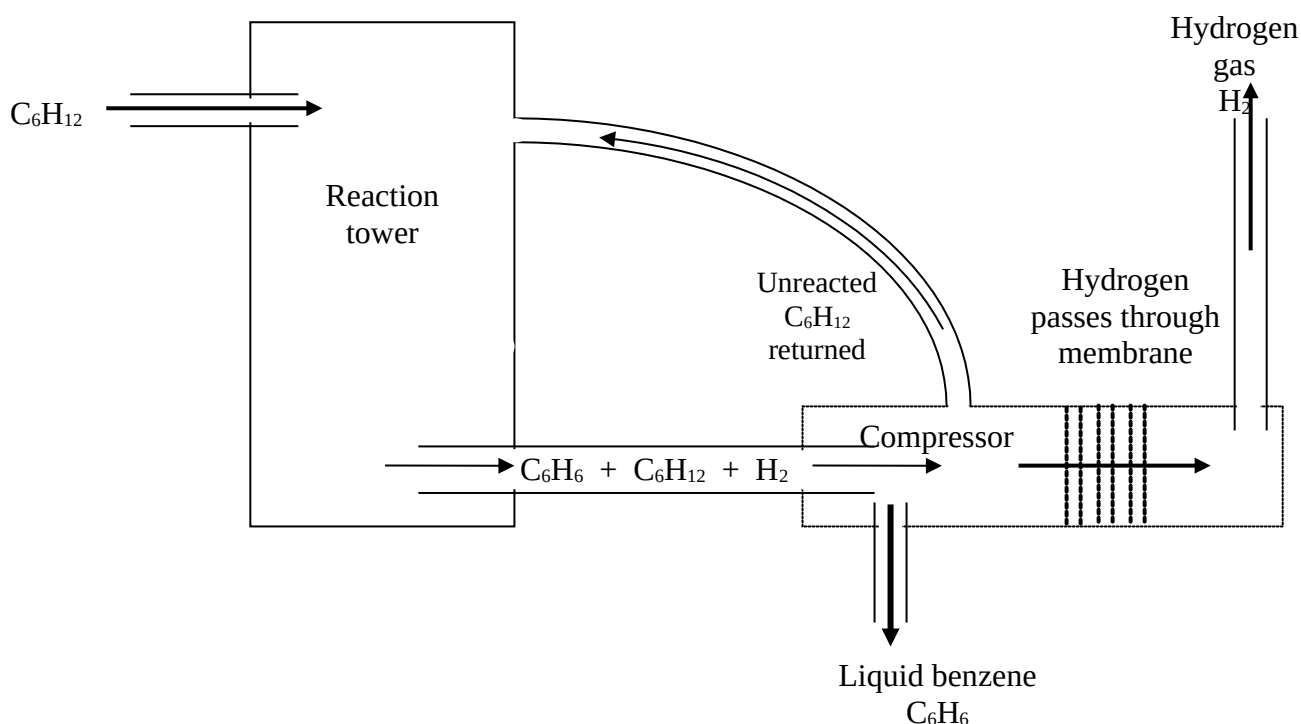
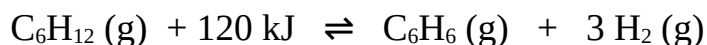
- a) What is the empirical formula of the compound? (10 marks)

[You may do this by finding the masses of carbon, hydrogen and oxygen in the sample]

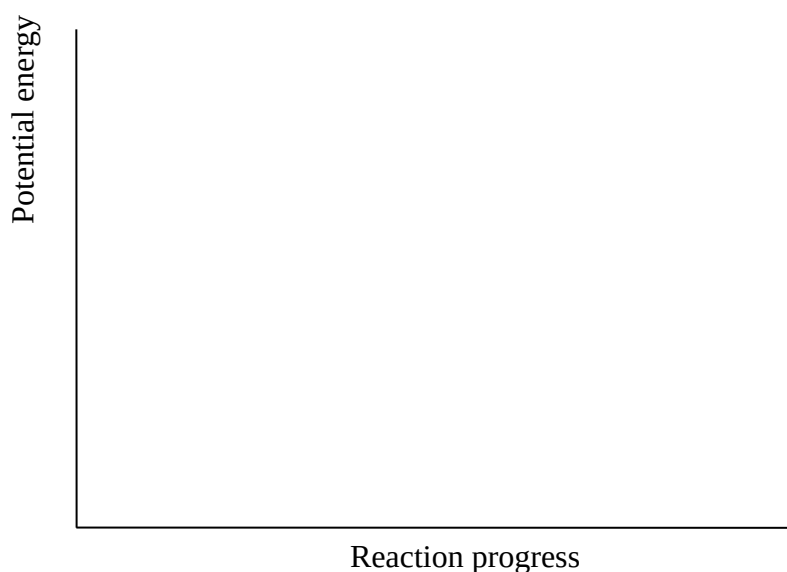
- b) What is the molecular formula of the compound? (3 marks)

4. **Production of benzene****14 marks**

Benzene (C_6H_6) can be produced by the dehydrogenation of cyclohexane (C_6H_{12}) gas. The reaction has a high activation energy (880 kJ mol^{-1}), is also endothermic and reversible. The cyclohexane (C_6H_{12}) passes through a special reaction tower where hydrogen is chemically removed. The benzene/cyclohexane/hydrogen mixture then passes through a compressor, where the benzene is liquefied. A special membrane in the compressor allows the small hydrogen molecules to pass through, and out. The unreacted cyclohexane (C_6H_{12}) gas is then returned to the reaction tower.



- a) Draw a labelled energy profile diagram for the reaction.



(3 marks)

- b) Write an equilibrium constant expression for the reaction.

(2 marks)

- c) Under what conditions will the rate of the forward reaction be greatest?

(3 marks)

- d) For a mixture of all three gases at equilibrium in a sealed container, what conditions will produce the maximum yield of benzene?

(2 marks)

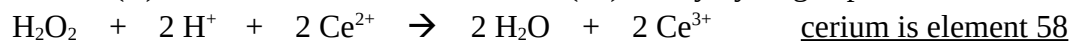
- e) Suggest conditions that would be used for the commercial production of benzene using this process.

Explain why you chose these conditions.

(4 marks)

5. Determining concentration of cerium (II) sulfate solution by titration 11 marks

Cerium (II) ion can be converted to cerium (III) ion by hydrogen peroxide.



A solution of cerium (II) sulfate was analysed by the following steps:

- I. 50.00 mL of the solution was diluted to 500.0 mL in a volumetric flask
- II. 20.00 mL of this diluted solution was pipetted into a conical flask
- III. About 20 mL of dilute sulfuric acid was added to the flask
- IV. Standardised hydrogen peroxide solution of concentration $0.05145 \text{ mol L}^{-1}$ was delivered from a burette
- V. 35.45 mL of the hydrogen peroxide was required for complete reaction

What was the concentration in moles per litre (mol L^{-1}) and in grams per litre (g L^{-1}) of the original undiluted cerium sulfate solution?

END OF PAPER