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# CHEMISTRY

## YEAR 12

## STAGE 3

## 2010

Name: \_\_\_\_\_

Teacher: \_\_\_\_\_

### *TIME ALLOWED FOR THIS PAPER*

**Reading time before commencing work: Ten minutes**

Working time for the paper: Three hours

### *MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER*

#### **To be provided by the supervisor:**

- This Question/Answer Booklet
- Multiple Choice Answer Sheet
- Data sheet

#### **To be provided by the candidate:**

- Standard items: Pens, pencils, eraser or correction fluid, ruler, highlighter.
- Special items: Calculators satisfying the conditions set by the Curriculum Council for this subject.

### *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.

**The Curriculum Council Chemical Data Sheet (Revised April 2010) should be used in conjunction with this paper.**

## 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

- The rules for the conduct of Curriculum Council examinations are detailed in the *Student Information Handbook*. Sitting this examination implies that you agree to abide by these rules.
- Answer the questions according to the following instructions:

### Section One

Answer **all** questions, using a 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet provided. Do not use a ball point or ink pen.

### Section Two

Answer in the spaces provided in this Question/Answer Booklet.

### Section Three

Write your answers in the Standard Answers Book.

- A blue or black ball point or ink pen should be used.
- 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  $NH_{3(g)}$ ,  $NH_{3(aq)}$ ,  $CH_3COOH_{(l)}$ ,  $CH_3COOH_{(aq)}$ ] or **solids** [for example  $BaSO_{4(s)}$ ,  $Cu_{(s)}$ ,  $Na_2SO_{4(s)}$ ]

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. Which of the following best describes the molecular shape and molecular polarity of a chloroform molecule whose formula is  $\text{CHBr}_3$ ?
- (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  $\text{kJmol}^{-1}$ )
- |     |      |      |       |       |
|-----|------|------|-------|-------|
| 680 | 1600 | 8000 | 11600 | 14500 |
|-----|------|------|-------|-------|
- What would be the formula of the compound formed when “X” reacts with oxygen ?
- (a)  $\text{X}_2\text{O}$
  - (b)  $\text{XO}$
  - (c)  $\text{X}_2\text{O}_3$
  - (d)  $\text{XO}_2$
3. When  $1.0 \text{ mol L}^{-1}$  solutions of the following are mixed, which combinations will result in the formation of precipitates?
- i)  $\text{Ba}(\text{NO}_3)_2$  and  $\text{HCl}$
  - ii)  $\text{Ca}(\text{NO}_3)_2$  and  $\text{Na}_2\text{CO}_3$
  - iii)  $\text{Cu}(\text{NO}_3)_2$  and  $\text{KOH}$
  - iv)  $\text{Pb}(\text{NO}_3)_2$  and  $\text{H}_2\text{SO}_4$
- (a) i), ii) and iii) only
  - (b) ii) and iii) only
  - (c) i), ii), iii) and iv)
  - (d) ii), iii) and iv) only
4. The conjugate base of the acid  $\text{HCrO}_4^-$  is:
- (a)  $\text{H}_2\text{CrO}_4$
  - (b)  $\text{H}_2\text{CrO}_4^-$
  - (c)  $\text{CrO}_4^{2-}$
  - (d)  $\text{CrO}_4^-$
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)  $\text{NaOH} + \text{HNO}_3 \rightarrow \text{NaNO}_3$
- (b)  $2\text{AgNO}_3 + \text{Cu} \rightarrow 2\text{Ag} + \text{Cu}(\text{NO}_3)_2$
- (c)  $\text{H}_2\text{SO}_4 + 2\text{KOH} \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$
- (d)  $\text{CaCl}_2 + \text{Ba}(\text{OH})_2 \rightarrow \text{Ca}(\text{OH})_2 + \text{BaCl}_2$

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

- (a)  $\text{SiO}_2$
- (b)  $\text{MgO}$
- (c)  $\text{NH}_4\text{Br}$
- (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.

9. A crystal of iodine,  $\text{I}_2$ , 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	$\text{I}_2$
(c)	dispersion forces	$\text{I}_2$
(d)	dipole-dipole	$\text{I}_2$

10. Household bleach contains sodium hypochlorite,  $\text{NaClO}$ , as the active ingredient. The concentration of  $\text{NaClO}$  in the bleach can be determined by reacting a known amount with aqueous hydrogen peroxide,  $\text{H}_2\text{O}_2$ , according to the equation:

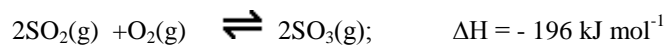


When 25.0 mL of bleach is treated with an excess of aqueous  $\text{H}_2\text{O}_2$ , 0.0350 mol of oxygen gas is given off.

What is the concentration of  $\text{NaClO}$  in the bleach?

- (a) 1.40 mol L<sup>-1</sup>
- (b) 0.700 mol L<sup>-1</sup>
- (c) 0.875 mol L<sup>-1</sup>
- (d) 8.75 x 10<sup>-4</sup> mol L<sup>-1</sup>

11. In the contact process reaction:



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

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

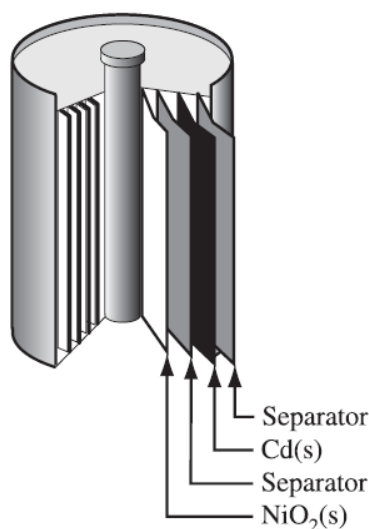


What does **not** occur in this reaction?

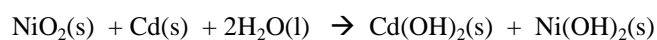
- (a) acid/base neutralisation
- (b) coordinate (dative) bond formation
- (c) oxidation/reduction
- (d) ionic bond formation

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:

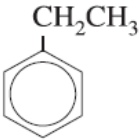
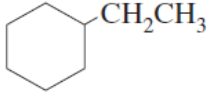
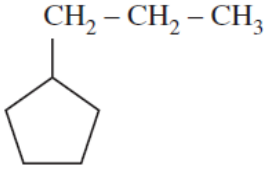
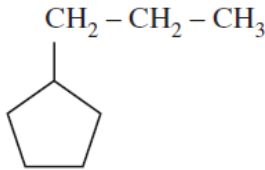


The reaction at the **anode** during the discharge of the cell is:

- (a)  $\text{Cd}(\text{s}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Cd}(\text{OH})_2(\text{s}) + 2\text{e}^-$
- (b)  $\text{Cd}(\text{s}) + 2\text{OH}^-(\text{aq}) + 2\text{e}^- \rightarrow \text{Cd}(\text{OH})_2(\text{s})$
- (c)  $\text{NiO}_2(\text{s}) + 2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{Ni}(\text{OH})_2(\text{s}) + 2\text{OH}^-(\text{aq})$
- (d)  $\text{NiO}_2(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{Ni}(\text{OH})_2(\text{s}) + 2\text{OH}^-(\text{aq}) + 2\text{e}^-$
14. Which one of the following has the same electronic arrangement as  $\text{Li}^+$ ?
- (a)  $\text{Na}^+$
- (b)  $\text{Be}^{2+}$
- (c)  $\text{F}^-$
- (d) Ne
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<sup>-1</sup> solution of hydrochloric acid.
- (b) 30.0 mL of a 0.300 mol L<sup>-1</sup> solution of iron(III) chloride.
- (c) 50.0 mL of a 0.200 mol L<sup>-1</sup> solution of magnesium chloride.
- (d) 50.0 mL of a 0.500 mol L<sup>-1</sup> solution of sodium chloride.

16. The IUPAC name for the structure below is:



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

20. When the compounds HF, H<sub>2</sub>O, NH<sub>3</sub>, and CH<sub>4</sub> are listed in order of increasing boiling point, which order is correct?

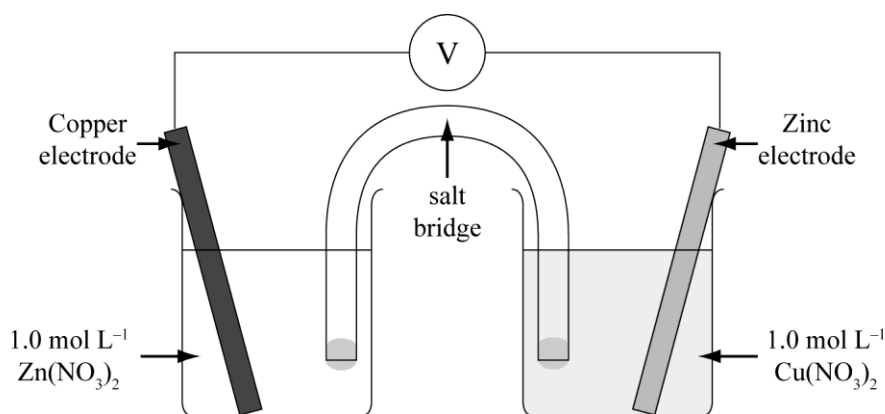
- (a) CH<sub>4</sub> < NH<sub>3</sub> < H<sub>2</sub>O < HF
- (b) NH<sub>3</sub> < CH<sub>4</sub> < H<sub>2</sub>O < HF
- (c) CH<sub>4</sub> < NH<sub>3</sub> < HF < H<sub>2</sub>O
- (d) HF < CH<sub>4</sub> < H<sub>2</sub>O < NH<sub>3</sub>

21. The reductant that can convert 1.0 M Fe<sup>3+</sup>(aq) to Fe<sup>2+</sup>(aq) but not 1.0 M Sn<sup>2+</sup>(aq) to Sn(aq), at STP is:

- (a) Cu(s)
- (b) Au(s)
- (c) Ni(s)
- (d) HOCCOOH(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  $-1.1\text{V}$  (at  $25\text{ }^\circ\text{C}$ ).
- (d) The concentration of  $\text{Cu}^{2+}$  ions will decrease.

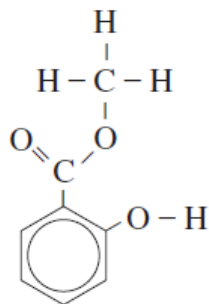
23. Which of the following statements is **correct**?

- (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.

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?

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

**SECTION 2**      **13 questions (80 marks 40 %)**

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

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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** \_\_\_\_\_

**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 (full or 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** \_\_\_\_\_

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

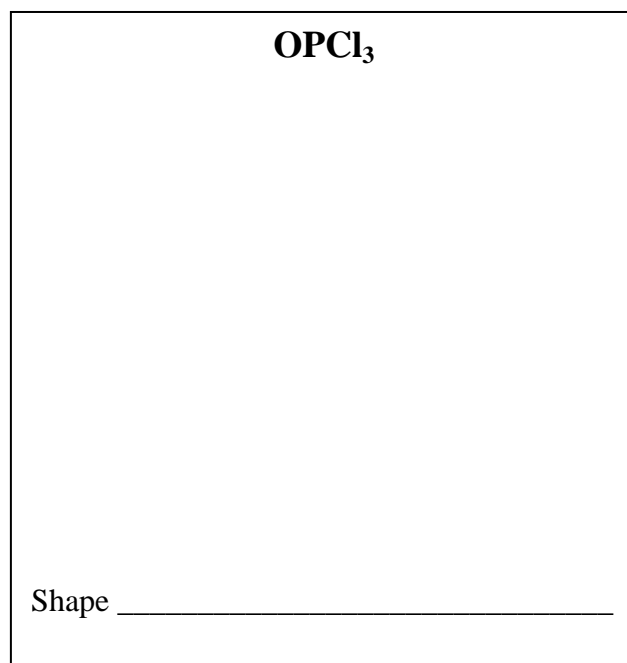
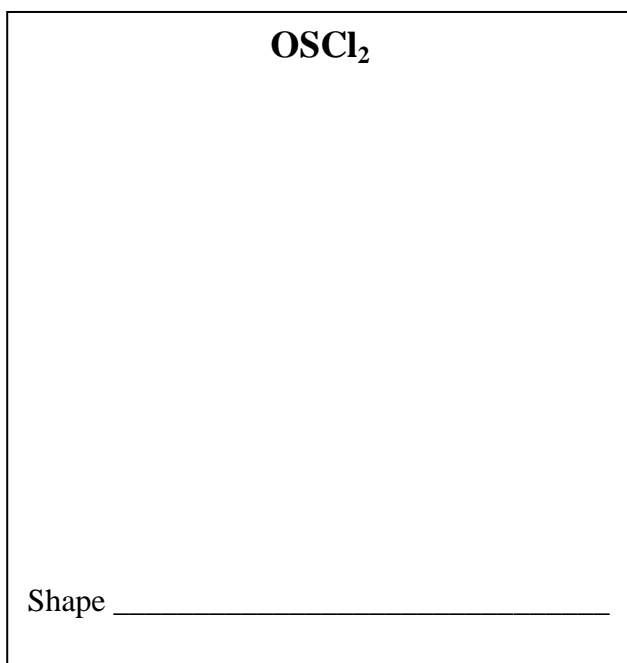
- b) A metal strip is placed in a green solution. Silvery-white crystals form on the strip and the green colour fades.

**Reaction** \_\_\_\_\_

**Equation** \_\_\_\_\_

(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 solubilities of two amines in water.

Amine	Methyl amine $\text{CH}_3\text{NH}_2$	Dodecyl amine $\text{CH}_3(\text{CH}_2)_{11}\text{NH}_2$
Solubility (g/100 mL)	108	0.05

Explain why their solubilities are so different.  
Include a labelled diagram.

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(6 marks)

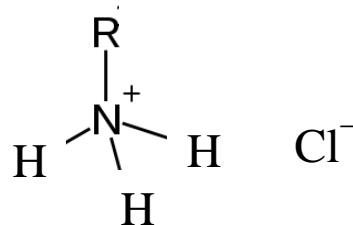


7. Quaternary ammonium salts can be represented by the following structural formula.

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.

Explain these two differences in properties.

Include a labelled diagram.



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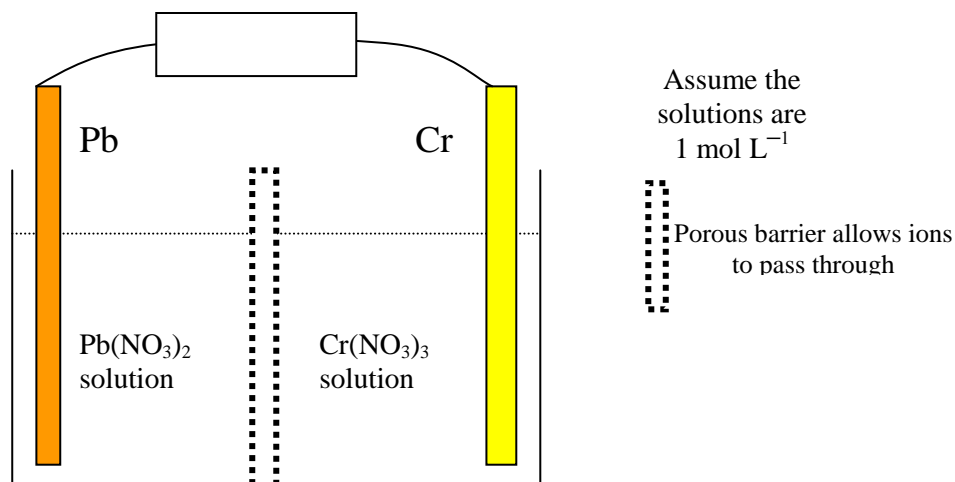
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(6 marks)

8. An electrochemical cell contains the 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 net redox equation.

\_\_\_\_\_

(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)





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	Oxidant, or reductant?
Concentrated sulfuric acid $\text{H}_2\text{SO}_4$	Reacts with copper to produce sulfur dioxide.	
Hydrogen peroxide $\text{H}_2\text{O}_2$	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.

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(3 marks)

12. Vinegar is about 4% by mass acetic acid and is safe to consume in foods. The same strength sulfuric acid is not safe to consume. Explain why. Include equations.

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(4 marks)

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

Compound	Structural diagram	Name
An isomer of dibromobutane		
An ester containing 4 carbon atoms		
The ketone with the least number of carbon atoms		

(9 marks)

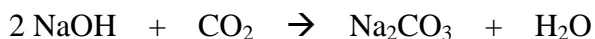
**SECTION 3**      **5 questions (70 marks 35 %)**

Extended answers

Answer ALL questions in Section 3 in the spaces provided.

**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 ( $\text{OH}^-$ ) concentration of  $1.00 \times 10^{-2} \text{ mol L}^{-1}$ .

(a) What is the pH of the solution?

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(2 marks)

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

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(3 marks)

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

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(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?

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(5 marks)

- (e) (i) The pond solution is still found to be alkaline (pH of about 9).  
Assuming all the carbon dioxide has reacted suggest a reason why is it still alkaline.

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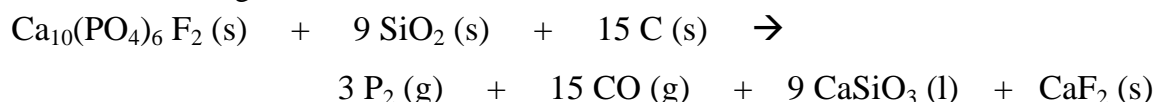
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(2 marks)

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 [ $\text{SiO}_2$ ] and powdered carbon in a high temperature furnace. The phosphorus is produced as a gas [ $\text{P}_2$ ], along with carbon monoxide. The reaction actually produces calcium oxide [ $\text{CaO}$ ], 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 [ $\text{CaSiO}_3$ ]. This liquid slag is easily separated from the furnace.

The reaction occurring is:



- (a) Is this reaction exothermic, or endothermic? \_\_\_\_\_  
Give a reason for your choice.

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(2 marks)

- (b) The main reaction can be represented by the two half reactions:
- phosphate ion producing phosphorus ( $\text{P}_2$ ) and oxide ions ( $\text{O}^{2-}$ ), 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.

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

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(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.

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(2 marks)

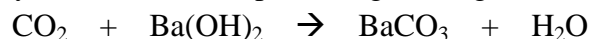


3. **Analysing an organic compound****13 marks**

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 ( $\text{BaCO}_3$ ).



- The mass of water produced by burning of the sample was 0.7721 g
- The compound was found to have a molecular weight of 150.1

- 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? (2 marks)

- c) The compound is also known to be a carboxylic acid; that is, containing one  $\text{COOH}$  group.

Write the molecular formula in the form of  $\text{C}_X\text{H}_Y\text{O}_Z\text{COOH}$  (giving values for X, Y and Z).

(1 mark)

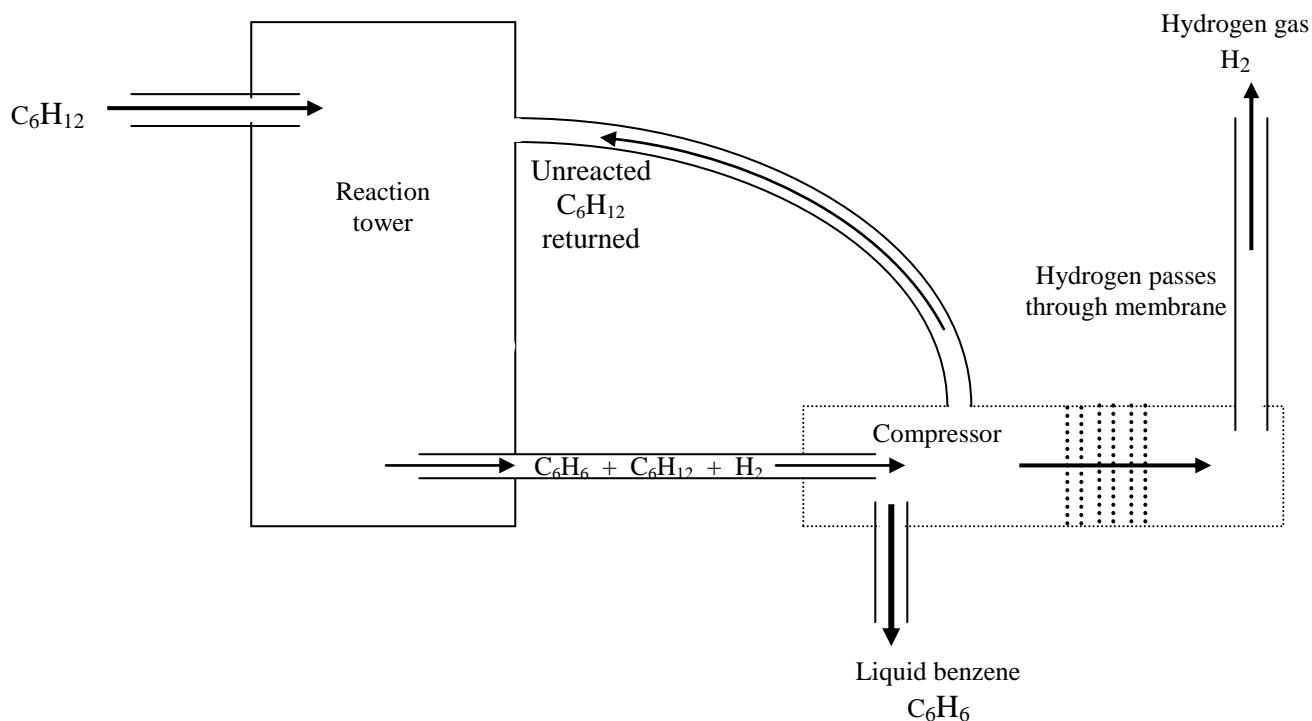
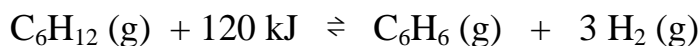




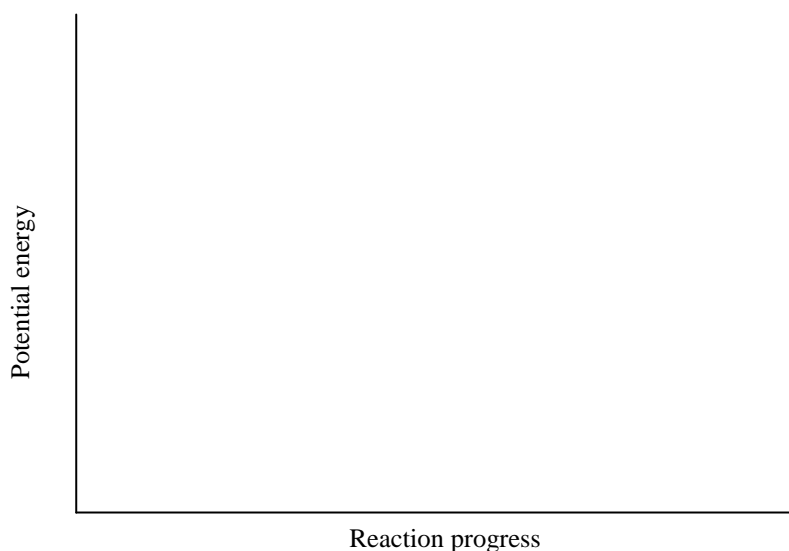
## 4. Production of benzene

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 ( $880 \text{ kJ mol}^{-1}$ ), 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?

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(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?

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(2 marks)

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

Explain why you chose these conditions.

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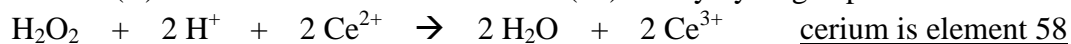
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(4 marks)

**5. Determining concentration of cerium (II) sulfate solution by titration 10 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 ( $\text{mol L}^{-1}$ ) and in grams per litre ( $\text{g L}^{-1}$ ) of the original undiluted cerium sulfate solution?













