Hilton College

Department of Physical Sciences

2013

Trial Examination

Chemistry PII

Marks: 200 **Time: 3 hours**

EXAMINER: Mr T van Niekerk

MODERATOR: Mr N Robert

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - A question paper of **22 pages** and **9 questions.**
   - Two pages of data and formulae (Pages 19 and 20) which can be detached.
   - An ANSWER SHEET (Pages 21 and 22) which can be detached.

2. Please check that your question paper is complete.

3. Read the questions carefully.
4. It is in your own interest to write legibly and to set your work out neatly.
5. Use the data and formulae whenever necessary.
6. Start each question on a new page of your answer book.
7. Number your answers in the same way as the questions are numbered.
8. All working must be shown.
9. Units need not be used in the calculations.
   They **MUST** be shown in the answers, however.

QUESTION 1

Choose the most correct answer from the options presented and record the answer on the answer grid, found on the inside of your answer booklet.

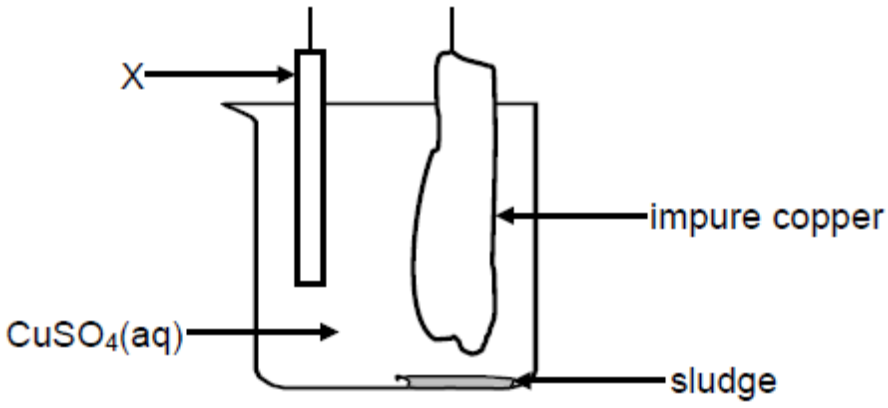
1.1 When the equilibrium constant of a reversible reaction has a value much greater than 1 ($K_c > 1$), it indicates that …

A a higher concentration of products than reactants will be formed.
B a lower concentration of products than reactants will be formed.
C the reaction will reach equilibrium quickly.
D the reaction will take a long time to reach equilibrium.

1.2 The equilibrium constants for the equilibrium reaction $4X(s) + 3Y_2(g) \rightleftharpoons 2X_2Y_3(s)$ are $3 X10^{-5}$ and $2 X 10^{-6}$ at temperatures 313 K and 333 K, respectively. Which one of the following statements is correct?

A For the forward reaction, $K_C = \frac{[X_2Y_3]^2}{[X]^4[Y_2]^3}$
B The forward reaction is endothermic
C The forward reaction is exothermic
D The forward reaction is favoured by a decrease in pressure

1.3 The diagram below represents a cell that may be used for refining copper. The impure copper contains silver metal and zinc metal.



Which ONE of the following half-reactions will take place at electrode X?

A $Ag^+ + e^- \rightarrow Ag$
B $Cu \rightarrow Cu^{2+} + 2e^-$
C $Cu^{2+} + 2e^- \rightarrow Cu$
D $Zn \rightarrow Zn^{2+} + 2e^-$

1.4 A commercial dry cell used in a torch is an example of a/an … cell.

A primary
B secondary
C electrolytic
D hydrogen

1.5 Which ONE of the following statements about the extraction of aluminium is TRUE?

A When the cell is in operation, aluminium forms at the anode.

B Aluminium oxide is dissolved in cryolite.

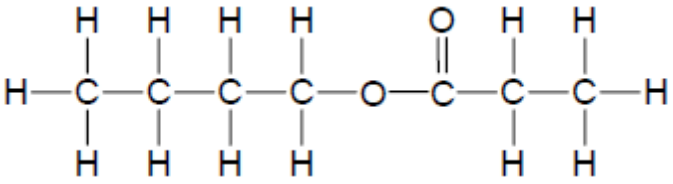
C When the cell is in operation, carbon dioxide gas forms at the cathode.

D The ore of aluminium oxide is called cryolite.

1.6 The acid produced during the Contact process is

A Nitric acid
B Sulphuric acid
C Hydrochloric acid
D Phosphoric acid

1.7 The structural formula of an ester is shown below.



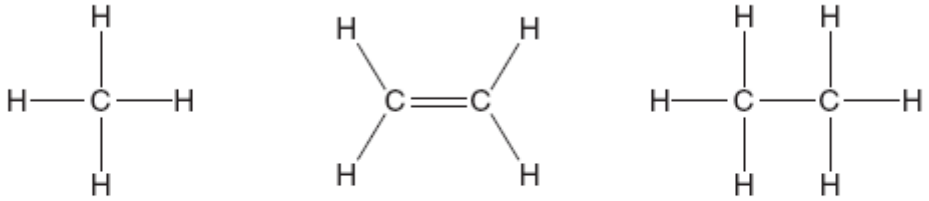
Which ONE of the following pairs of compounds can be used to prepare the above ester?

A Propanoic acid and butan-1-ol
B Propanoic acid and butan-2-ol
C Butanoic acid and propan-1-ol
D Butanoic acid and propan-2-ol

1.8 Which ONE of the following reaction types can be used to prepare ethene from octane?

A Addition
B Hydrogenation
C Cracking
D Substitution

1.9 The diagrams below show the structures of three compounds.



P Q R

Which compounds belong to the same homologous series?

A P and Q only
B P and R only
C Q and R only
D P, Q and R

1.10 Bromine water loses its colour when propene gas is bubbled through it.
Which one of the following compounds is the product of this reaction?

A 1,2 - dibromopropene
B 1,1 - dibromopropane
C 1,1,2,2 - tetrabromopropane
D 1,2 - dibromopropane

[10 x 2 = 20]

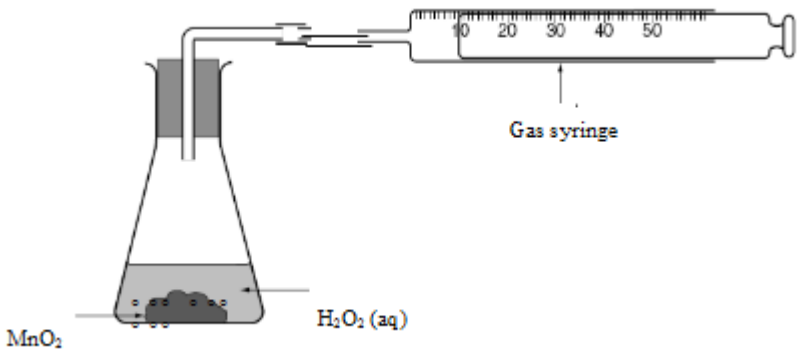
QUESTION 2

Hydrogen peroxide solution ($H_2O_2(aq)$) undergoes a spontaneous but slow decomposition to form water and oxygen gas. The reaction can, however, be catalyzed using manganese dioxide (MnO_2) as shown in the equation below.

$$2\,H_2O_2(aq) \xrightarrow{\text{catalyst } MnO_2} 2\,H_2O(\ell) + O_2(g) \qquad \Delta H = -98{,}2\ kJ.mol^{-1}\ H_2O_2$$

An experimental investigation is carried out on the decomposition of an aqueous solution of hydrogen peroxide, ($H_2O_2(aq)$), initially in the absence and then in the presence of the catalyst, manganese dioxide (MnO_2), using the apparatus shown.

The oxygen, ($O_2(g)$), is collected in a gas syringe, and its volume is measured every minute, so that the rate of the reaction can be determined.



2.1 Give a suitable hypothesis for this investigation. (2)

2.2 Identify the independent variable in each experiment. (1)

2.3 Identify the dependent variable in each experiment. (1)

2.4 In an experiment that works well, explain why some variables need to be controlled. (2)

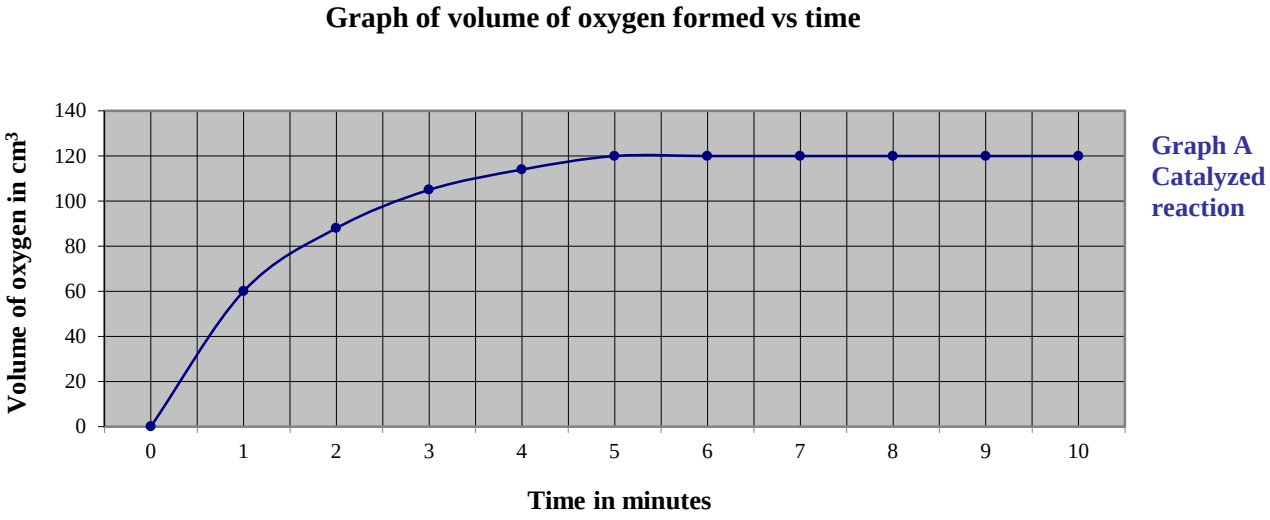
2.5 State three variables that need to be controlled throughout this investigation. (3)

2.6 The experiment is conducted using the apparatus shown above. After the initial uncatalysed experiment, the catalyst, manganese dioxide (MnO_2) is added to the hydrogen peroxide solution and the conical flask is quickly stoppered with a rubber bung. Discuss at least two possible experimental errors, and state how each error could be avoided or minimized. (4)

2.7 What observation would have been made when the catalyst manganese dioxide (MnO_2) was added to the hydrogen peroxide solution? (2)

2.8 State the definition of a catalyst. (2)

Assume 0,1 g of manganese dioxide (MnO_2) was added to the 2 mol.dm^{-3} solution of hydrogen peroxide (H_2O_2(aq)) at 20°C (293 K) and the volume of gas produced was collected at standard pressure, and measured every minute using a gas syringe. The results obtained are plotted and shown in the Graph A below:



2.9 The graph A above, is replicated on the **answer sheet**. On the same set of axes,

2.9.1 draw a **sketch graph labelled B** which would represent the results for the **uncatalysed reaction**.
(Assume this reaction is completed within 10 minutes). (2)

2.9.2 draw a **sketch graph labelled C** which would represent the results if 0,1 g of manganese dioxide was added to 1 mol.dm^{-3} solution of hydrogen peroxide at 20°C. (2)

2.10 Use collision theory to explain why the gradient of graph A decreases as the reaction proceeds. (2)

2.11 By which time was the catalysed reaction (graph A) complete? (1)

[24]

QUESTION 3

The equation below represents an equilibrium reaction that occurs in a 1 dm^3 container.

$$NO_{2\,(g)} + NO_{(g)} \rightleftharpoons N_2O_{(g)} + O_{2\,(g)} \quad \Delta H > 0$$

3.1 State Le Chatelier's Principle. (3)

3.2 What is the meaning of the symbol $\rightleftharpoons$ in the equation above? (2)

3.3 Write the letters **a – i** on your answer paper and next to each one write a suitable word to complete the table below.
Use the words **increases, decreases or remains constant.**

Change	Yield of oxygen	Equilibrium constant	Rate of forward reaction
Pressure is increased by decreasing volume at constant temperature	a	b	c
Temperature is increased at constant volume	d	e	f
Extra oxygen is pumped into the container	g	h	i

(9)

3.4 The concentration of each reactant and product at equilibrium were as follows.

$[NO_2] = 0{,}06\ mol.dm^{-3}$ $[NO] = 0{,}29\ mol.dm^{-3}$

$[N_2O] = 0{,}18\ mol.dm^{-3}$ $[O_2] = 0{,}38\ mol.dm^{-3}$

3.4.1 Calculate the value of Kc at equilibrium. (4)

3.4.2 One of the conditions effecting the equilibrium was changed which resulted in a **decrease** in the value of the equilibrium constant Kc.
Which condition, concentration or temperature caused this change? (1)

3.4.3 Give an explanation to your answer in question 3.4.2.as to why there is a **decrease** in the value of the equilibrium constant Kc. (2)

3.5 Water ionizes according to the reaction:

$$2\ H_2O_{(\ell)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

The expression for the equilibrium constant for this reaction is given on your data sheet as: $K_w = [H_3O^+].[OH^-] = 1 \times 10^{-14}$ at 298 K (25^oC)

3.5.1 What does the value of the equilibrium constant for water (K_w) indicate regarding water's ability to ionize at 298K? (1)

3.5.2 Why is it necessary to give the temperature (298 K) when giving the value for the equilibrium constant? (2)

3.5.3 In a sample of pure water, at 298 K, what would you expect the concentration of H_3O^+ ions to be? (2)

[26]

QUESTION 4

A standard galvanic (voltaic) cell has a zinc anode. An unknown substance **X** is the cathode.

4.1 State the two standard conditions that are applicable to the $Zn^{2+}|Zn$ half cell. (2)

4.2 Name or give the formula of a suitable electrolyte that can be used in the $Zn^{2+}|Zn$ half cell. (1)

4.3 Identify the reducing agent in this galvanic cell. (1)

4.4 If the initial emf of this galvanic cell is 1,72 V, identify the unknown substance **X**. Show all calculations. (5)

4.5 Write down the cell notation for this cell. (4)

4.6 State the energy conversion in this cell. (1)

4.7 If the concentration of the electrolyte in the $Zn^{2+}|Zn$ half cell is increased, how will the initial emf of the cell change? Write only INCREASES, DECREASES or REMAINS THE SAME. (1)

4.8 Using the net cell reaction, give an explanation for your answer in 4.7. (3)

4.9 The reaction in this galvanic cell reaches equilibrium. A voltmeter is connected across its electrodes.

4.9.1 Write down the value of the reading on the voltmeter. (1)

4.9.2 Give an explanation for your answer in 4.9.1. (2)

4.9.3 "When equilibrium is reached, all the reactions in the cell stop." Is this statement correct? Answer YES or NO. (1)

4.9.4 Using a suitable half reaction, give an explanation for your answer in 4.9.3 (3)

[25]

QUESTION 5

Jennifer and Dashnie designed an experiment to test the capacity of two different brands of battery.

The girls sourced four appliances which specified the current drawn and each operated using one 1,5 V AA battery.

Battery A

Battery B

Animal lights

Small gift torch

Dancing Santa

Toothbrush

The girls then measured how long each appliance ran continuously with the two different batteries. Their results are tabulated in Table 1.

Table 1: Data for battery comparison

			Battery A	Battery B
	Current drawn, I (A)	Inverse of current, $1/I$ (A^{-1})	Time of operation, t (min)	Time of operation, t (min)
Animal light	0,5		305	264
Small gift torch	1		160	132
Dancing Santa	1,5		90	88
Toothbrush	2		70	66

5.1 When each battery is being tested, what is the independent variable? (1)

5.2 Give one important control variable for this experiment. (1)

5.3 Table 1 above is replicated on the answer sheet. Calculate and fill in the values for the column labeled **inverse current** $^{1}/_{I}$. (2)

5.4 Plot graphs of t versus the inverse current $^{1}/_{I}$ for both batteries on the same set of axes. Draw a best-fit straight line through the origin for each set of battery data. (8)

5.5 Determine the capacity of battery A in **mAh** by calculating the gradient of graph A. (5)

5.6 Both of these batteries are **alkaline dry cells** which have a much greater capacity than cheaper **Leclanché dry cells**.

5.6.1 Why are they both termed "dry" cells? (1)

5.6.2 Other than the price and capacity, what is the main difference between an alkaline dry cell and a Leclanché cell? (2)

5.6.3 These two types of cell have exactly the same size and shape. In the light of this fact, explain how it is possible for the alkaline cells to have a greater capacity. (2)

5.7 The half-cell reactions in an alkaline dry cell are as follows:

$$Zn + 2OH^- \rightarrow ZnO + H_2O + 2\ e^-$$
$$2\ MnO_2 + H_2O + 2\ e^- \rightarrow Mn_2O_3 + 2\ OH^-$$

5.6.1 Which chemical particle justifies the use of the word "alkaline"? (1)

5.6.2 Write down the overall cell reaction. (2)

5.8 The batteries pictured below are much more expensive than the batteries used by the girls in their experiment. State and explain the significant difference between the type of batteries pictured below and the batteries used by the girls. (2)

5.9 For which of the appliances/toys used in this experiment might using the more expensive batteries be better in the long term? Justify your choice. (2)

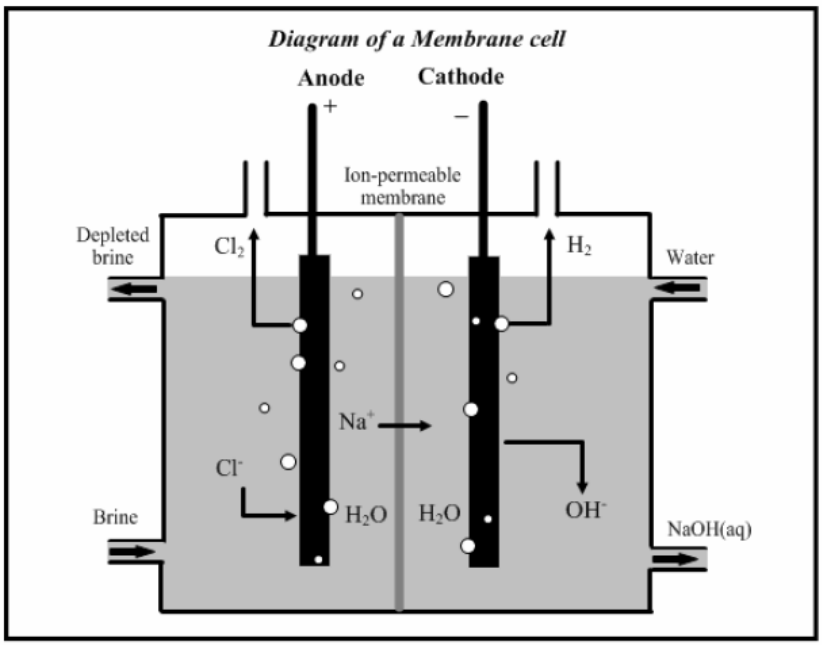
5.10 Parents spend a lot of money on buying toys for their children at Christmas time. Explain the irony or sarcasm referred to by Bernard Manning in the quote. (2)

> "I once bought my kids a set of batteries for Christmas with a note on it saying, toys not included."
> - Bernard Manning

[31]

QUESTION 6

There are three different industrial processes that use electrolytic cells to produce chlorine from brine. These processes are known as the diaphragm process, the mercury cathode process and the membrane process. Below is a diagram of a membrane cell



6.1 Use the equations from the Table of Reduction Potentials to write down the half-reactions taking place at the:

6.1.1 anode and the (2)

6.1.2 cathode (2)

6.2 Use the values from the Table of Reduction Potentials to show that this reaction is **not** spontaneous. (5)

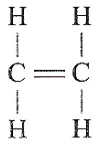
6.3 Use the diagram above to identify the **names** of the three useful products of this cell and write down a use of each one. (6)

6.4 The mercury cathode process and the diaphragm process are currently being phased out. Explain why these two processes are both harmful to the environment. **(Two marks per valid point**) (4)

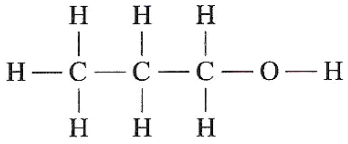
[19]

QUESTION 7

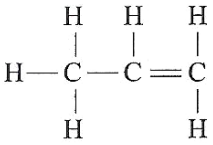
7.1 The formulae for four compounds are given below:



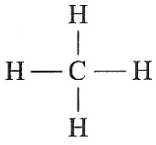
A



B



C



D

Match formulae, A, B, C and D, with the numbers 7.1.1 – 7.1.4 in the table. Write only the number and the letter of your choice.

	Description
7.1.1	It is an unsaturated hydrocarbon with three carbon atoms in each molecule
7.1.2	It is the monomer from which poly(ethene) is made
7.1.3	It has the lowest melting point
7.1.4	It is not a hydrocarbon

(4)

7.2 Haloalkanes, such as $CH_3C\ell$, are used in organic synthesis.

Questions 7.2.1 to 7.2.4 outline a **three - step synthesis** of $CH_3CH_2CH_2OH$.

7.2.1 The **first step** starts with methane, in a substitution reaction, to form $CH_3C\ell$. Using structural formulae, write an equation representing this step. (4)

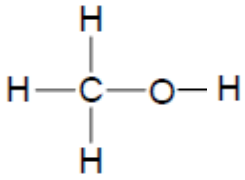
The **second step** is an addition reaction between $CH_3C\ell$ and CH_2CH_2 as represented by the equation $CH_3C\ell + CH_2CH_2 \rightarrow CH_3CH_2CH_2C\ell$

7.2.2 Name the product of the **second** step. (2)

7.2.3 Name the reactant CH_2CH_2 of the **second** step. (1)

7.2.4 The **third step** should be a substitution reaction to form $CH_3CH_2CH_2OH$. Using structural formulae, write an equation representing this step. (3)

7.3 Methanol has the following structure:



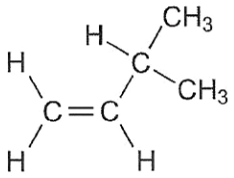
7.3.1 Explain why the O – H bond in a methanol molecule is polar. (2)

7.3.2 The boiling point of methanol is +65°C; the boiling point of oxygen is -183°C. Methanol and oxygen both have a relative molecular mass, M_r, of 32. Explain, in terms of the intermolecular forces present in each case, why the boiling point of methanol is much higher than that of oxygen. (3)

7.4 Pent-1-ene is a member of the alkene homologous series.

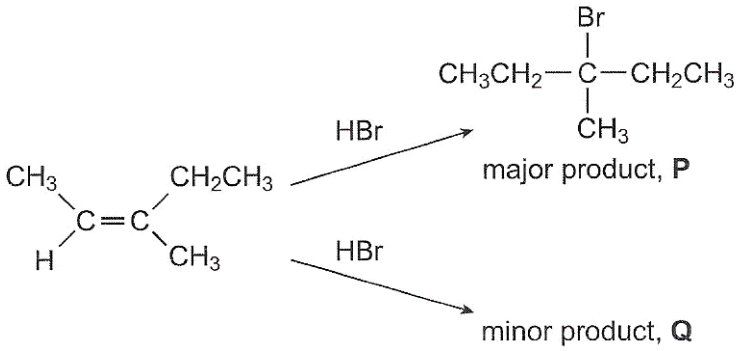
7.4.1 State the meaning of the terms “structural isomerism” and “homologous series”. (4)

7.4.2 Name the branched chain isomer of pent-1-ene shown below:



(3)

7.5 The alkene, 3-methylpent-2-ene reacts with hydrogen bromide as shown below:



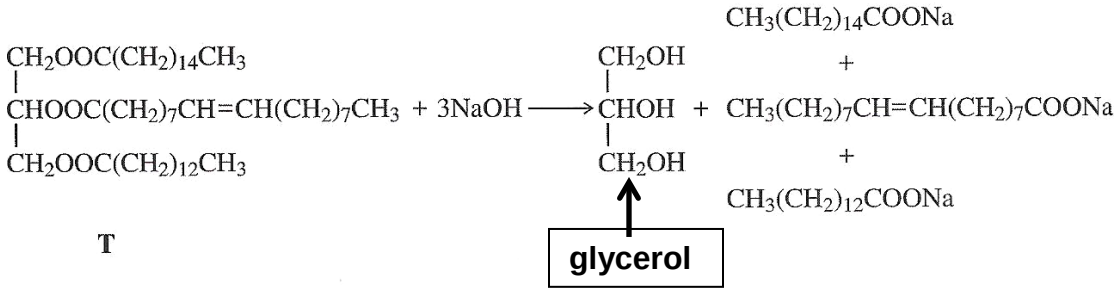
7.5.1 Name the major product, **P**. (2)

7.5.2 Major product, P, can be converted back to the alkene, 3-methylpent-2-ene. Name this type of reaction. (2)

[30]

QUESTION 8

The triester, **T**, shown below is found in palm oil. When **T** is heated with an excess of sodium hydroxide solution, the alcohol glycerol is formed together with a mixture of three other products as shown in the following equation:



8.1 Draw the structural formula of the main functional group found in any ester. (2)

8.2 Give the IUPAC name for glycerol. (2)

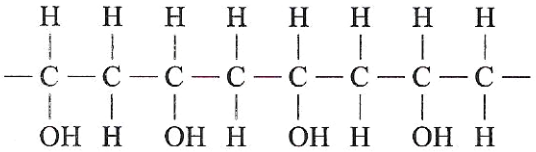
8.3 Give one distinctive property of esters. (2)

8.4 Name the condition, and the catalyst used, in the formation of triester T. (2)

[8]

QUESTION 9

Poly(vinyl alcohol) has this structure:



9.1 What is a polymer? (2)

9.2 Give the structural formula for the monomer from which poly(vinyl alcohol) is made. (2)

9.3 How many repeat units of this monomer are shown in the polymer? (2)

9.4 What type of polymerisation is this? (2)

9.5 Read parts of an article on the next page and answer the questions below:

9.5.1 Which type of plastic, thermoplastic or thermoset, is easier to recycle? (2)

9.5.2 Give two advantages plastic has over other materials in the car industry. (2)

9.5.3 What is the major disadvantage of plastic? (2)

9.5.4 **"Ah, priorities. For many, green still takes a backseat to convenience."**

Take a stand on this quote from the passage by writing 3 sentences. (3)

[17]

GOING GREEN

The Promise And Pitfalls of Bioplastic. It's a greener alternative, but think twice before you throw it away

BY KRISTINA DELL

REGULAR, PETROLEUM-BASED PLASTIC doesn't biodegrade. But this year's crop of Earth Day–inspired ads shows plant-based plastics doing just that: an empty SunChips bag fading into the soil, a Paper Mate pen dissolving underground. Although the visuals suggest that these items simply disintegrate (Goodbye, landfill!), the reality is more complicated. Take the SunChips bag. It needs to go in a compost bin; the packaging is clear about that. Likewise, Paper Mate notes that the pen's outer casing will break down if buried in a backyard but that its innards should go in the garbage. Forget to separate them, and the outer part won't biodegrade in a landfill.

Bioplastics could be really good for the environment—the manufacturing process produces fewer greenhouse-gas emissions than that for petroleum-based plastics, and these biomaterials don't contain an allegedly hormone-disrupting chemical, bisphenol A (BPA), that some regular plastics do. But is society green enough to use bioplastics? Many of us still don't recycle all our bottles and cans, and now companies are expecting us to start composting?

Bioplastics have been around for decades. Henry Ford made parts for the Model T out of corn and soybean oils

Many of the disposal issues could be resolved if manufacturers follow Bakx's suggestion and adopt a uniform color to identify bioplastic resins. Until then, Naturally Iowa is selling its PLA water bottles only in places like hotels and cafeterias, like the ones used by Congress and the U.S. Department of Agriculture, where the company can pick up and recycle the plastic waste. Says CEO Bill Horner: "We want to touch the bottle after it's used and know where it is going to go."

Breaking our petroleum addiction won't be easy. But the more pain we feel at the pump—U.S. gas prices are expected to go back up to $3 a gal. (80¢ per L) this summer—the more we'll be willing to adapt. For now, many SunChips purchasers are complaining not about the lack of industrial composting sites but about how much noise the new bag makes. "I tried to sneak some SunChips at night, and I woke my wife up," says Bob O'Connell, a compliance officer in New Port Richey, Fla. "That's how loud the bag is." Ah, priorities. For many, green still takes a backseat to convenience. ■

Headed for a Breakdown.
How a new corn-based plastic returns to the soil

Day 1

This Target gift card looks and feels like regular plastic, but it's made of a **plant-based material**, Mirel PHA, that will **biodegrade** in a compost bin. It's also the only type of bioplastic that will break down in soil or streams

Day 40

Mirel PHA eventually decomposes into carbon dioxide and water. But if it gets buried in a **landfill** and moisture seeps in, it could give off **methane**, a potent greenhouse gas

DATA SHEET: PHYSICAL SCIENCE PII

TABLE 1 PHYSICAL CONSTANTS

Standard pressure	p^{θ}	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP	V_m	$22{,}4$ dm^3.mol^{-1}
Standard temperature	T^{θ}	273 K

TABLE 2 FORMULAE

$n = \frac{m}{M}$ $c = \frac{n}{V}$	$E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$
$W = V.Q \qquad W = V.I.t$ $Q = I.\Delta t$	$K_w = [H^+][OH^-] = 10^{-14}$ at 298 K

TABLE 3 PERIODIC TABLE

Key

Atomic number (Z) | Electronegativity | Relative atomic mass

Example: 1 2.1 **H** 1

	I	II											III	IV	V	VI	VII	0
1	1 2.1 **H** 1																	2 **He** 4
2	3 1.0 **Li** 7	4 1.5 **Be** 9											5 2.0 **B** 10.8	6 2.5 **C** 12	7 3.0 **N** 14	8 3.5 **O** 16	9 4.0 **F** 19	10 **Ne** 20
3	11 0.9 **Na** 23	12 1.2 **Mg** 24.3											13 1.5 **Aℓ** 27	14 1.8 **Si** 28	15 2.1 **P** 31	16 2.5 **S** 32	17 3.0 **Cℓ** 35.5	18 **Ar** 40
4	19 0.8 **K** 39	20 1.0 **Ca** 40	21 1.3 **Sc** 45	22 1.5 **Ti** 48	23 1.6 **V** 51	24 1.6 **Cr** 52	25 1.5 **Mn** 55	26 1.8 **Fe** 56	27 1.8 **Co** 59	28 1.8 **Ni** 59	29 1.9 **Cu** 63.5	30 1.6 **Zn** 65.4	31 1.6 **Ga** 70	32 1.8 **Ge** 72.6	33 2.0 **As** 75	34 2.4 **Se** 79	35 2.8 **Br** 80	36 **Kr** 84
5	37 0.8 **Rb** 85.5	38 1.0 **Sr** 88	39 1.2 **Y** 89	40 1.4 **Zr** 91	41 1.6 **Nb** 93	42 1.8 **Mo** 96	43 1.9 **Tc** 99	44 2.2 **Ru** 101	45 2.2 **Rh** 103	46 2.2 **Pd** 106	47 1.9 **Ag** 108	48 1.7 **Cd** 112	49 1.7 **In** 115	50 1.8 **Sn** 119	51 1.9 **Sb** 121	52 2.1 **Te** 128	53 2.5 **I** 127	54 **Xe** 131
6	55 **Cs** 133	56 **Ba** 137.3		72 **Hf** 178.5	73 **Ta** 181	74 **W** 184	75 **Re** 186	76 **Os** 190	77 **Ir** 192	78 **Pt** 195	79 **Au** 197	80 **Hg** 200.6	81 **Tℓ** 204.4	82 **Pb** 207	83 **Bi** 209	84 **Po** -	85 **At** -	86 **Rn** -
7	87 **Fr**	88 **Ra**																

57 **La**	58 **Ce**	59 **Pr**	60 **Nd**	61 **Pm**	62 **Sm**	63 **Eu**	64 **Gd**	65 **Tb**	66 **Dy**	67 **Ho**	68 **Er**	69 **Tm**	70 **Yb**	71 **Lu**
89 **Ac**	90 **Th**	91 **Pa**	92 **U**	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lw**

TABLE 4 STANDARD ELECTRODE POTENTIALS

Half –reaction			E°/ volt
$Li^+ + e^-$	⇌	Li	-3.05
$K^+ + e^-$	⇌	K	-2.93
$Cs^+ + e^-$	⇌	Cs	-2.92
$Ba^{2+} + 2e^-$	⇌	Ba	-2.90
$Sr^{2+} + 2e^-$	⇌	Sr	-2.89
$Ca^{2+} + 2e^-$	⇌	Ca	-2.87
$Na^+ + e^-$	⇌	Na	-2.71
$Mg^{2+} + 2e^-$	⇌	Mg	-2.37
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	-1.66
$Mn^{2+} + 2e^-$	⇌	Mn	-1.18
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	-0.83
$Zn^{2+} + 2e^-$	⇌	Zn	-0.76
$Cr^{2+} + 2e^-$	⇌	Cr	-0.74
$Fe^{2+} + 2e^-$	⇌	Fe	-0.44
$Cd^{2+} + 2e^-$	⇌	Cd	-0.40
$Co^{2+} + 2e^-$	⇌	Co	-0.28
$Ni^{2+} + 2e^-$	⇌	Ni	-0.25
$Sn^{2+} + 2e^-$	⇌	Sn	-0.14
$Pb^{2+} + 2e^-$	⇌	Pb	-0.13
$Fe^{3+} + 3e^-$	⇌	Fe	-0.04
$2H^+ + 2e^-$	⇌	$H_2(g)$	0.00
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+0.14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+0.15
$Cu^{2+} + e^-$	⇌	Cu^+	+0.16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+0.17
$Cu^{2+} + 2e^-$	⇌	Cu	+0.34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+0.40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+0.45
$I_2 + 2e^-$	⇌	$2I^-$	+0.54
$O_2(g) + 2H^+ + e^-$	⇌	H_2O_2	+0.68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+0.77
$Hg^{2+} + 2e^-$	⇌	Hg	+0.79
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+0.80
$Ag^+ + e^-$	⇌	Ag	+0.80
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+0.96
$Br_2 + 2e^-$	⇌	$2Br^-$	+1.09
$Pt^{2+} + 2e^-$	⇌	Pt	+1.20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+1.21
$O_2 + 4H^+ + 4e^-$	⇌	$2H_2O$	+1.23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+1.33
$C\ell_2 + 2e^-$	⇌	$2C\ell^-$	+1.36
$Au^{3+} + 3e^-$	⇌	Au	+1.42
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+1.51
$H_2O_2 + 2H^+ + e^-$	⇌	$2H_2O$	+1.77
$F_2(g) + 2e^-$	⇌	$2F^-$	+2.87

Increasing oxidising ability ↓

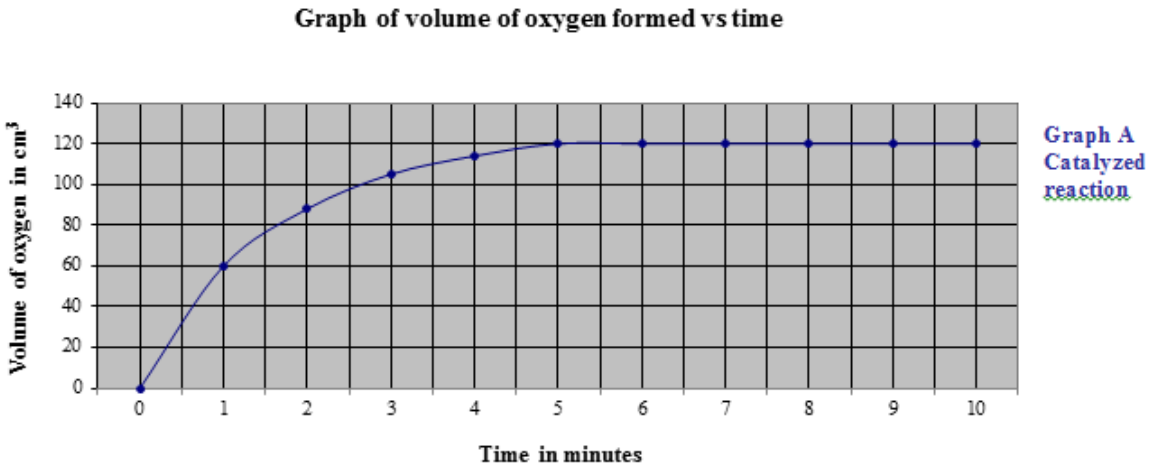
Increasing reducing ability ↑

Detach this page and hand it in with your answer script

ANSWER SHEET

EXAMINATION NUMBER: _____

QUESTION 2.9



QUESTION 5.3

Table 1: Data for battery comparison

			Battery A	Battery B
	Current drawn, I (A)	Inverse of current, $1/I$ (A^{-1})	Time of operation, t (min)	Time of operation, t (min)
Animal light	0,5		305	264
Small gift torch	1		160	132
Dancing Santa	1,5		90	88
Toothbrush	2		70	66

(2)

QUESTION 5.3 (8)