CHEMISTRY

YEAR 12

STAGE 3

2011

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.

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	60 minutes	12	12	70
THREE: Extended response	70 minutes	7	7	80
			[Total marks]	200

Instructions to candidates

1. 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.

2. 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.

3 A blue or black ball point or ink pen should be used.

4. 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 $NH_{3(g)}$, $NH_{3(aq)}$, $CH_3COOH_{(\ell)}$, $CH_3COOH_{(aq)}$] or **solids** [for example $BaSO_{4(s)}$, $Cu_{(s)}$ $Na_2SO_{4(s)}$]

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

Answer ALL questions in Part 1 on the Separate Multiple Choice Answer Sheet provided, using a 2B pencil. Each question in this part is worth 2 marks.

---

1. Which of the following elements has the highest second ionisation energy?

   (a) Calcium
   (b) Magnesium
   (c) Potassium
   (d) Sodium

2. An element, E, is able to react to form both ionic and covalent compounds. How many valence electrons would its atoms most likely possess?

   (a) 1
   (b) 2
   (c) 7
   (d) 8

3. In which of the following pairs of atomic species is the first species larger than the second species?

   (a) sodium ion sodium atom
   (b) oxide ion sulfide ion
   (c) calcium atom magnesium ion
   (d) potassium ion potassium atom

4. Three of the following species have the same number of protons. Which has the different number of protons?

   (a) carbonium ion CH_3^+
   (b) neon ion Ne^+
   (c) fluoride ion F^-
   (d) amide ion NH_2^-

5. Which of the following statements about graphite and silicon dioxide is true?

   (a) Both have atoms bonded together by sharing electrons.
   (b) Both have delocalised electrons.
   (c) Graphite has a very high melting point while silicon dioxide has a very low melting point.
   (d) Silicon dioxide is ionic while graphite is metallic.

6. What is the shape of a water molecule?

(a) Linear
(b) Bent (V–shape)
(c) Pyramidal
(d) Tetrahedral

7. Which type of bonding is not present in solid hydrogen chloride?

(a) covalent
(b) dipole – dipole
(c) dispersion force
(d) hydrogen bonding

8. The boiling points of a family of trihalomethanes (CHX_3) are listed below.

Trifluoromethane	CHF_3	–89 ^oC
Trichloromethane	$CHCl_3$	61 ^oC
Tribromomethane	$CHBr_3$	150 ^oC
Triiodomethane	CHI_3	330 ^oC

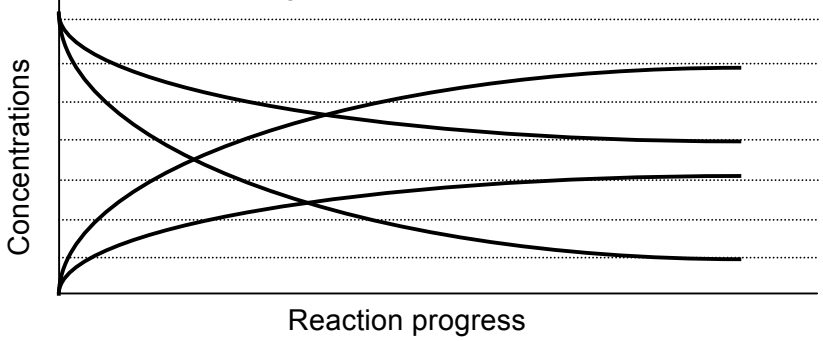
The increase in boiling points moving down the list is due to an increase in the strength of

(a) covalent bonding.
(b) dispersion forces.
(c) dipole-dipole bonding.
(d) hydrogen bonding.

9. Which of the following **saturated solutions** has the highest concentration of ions?

(a)	zinc carbonate	$ZnCO_3$
(b)	calcium phosphate	$Ca_3(PO_4)_2$
(c)	silver sulfate	Ag_2SO_4
(d)	barium hydroxide	$Ba(OH)_2$

10. Dylan mixes two gases in a sealed flask. They react to produce two new gases. However, the reaction is reversible and soon equilibrium is established. The following graph shows the concentrations of the four gases as equilibrium is established.



Which of the following equations represents the reaction?

(a) $Cl_2O_7 + 2\ CO \rightleftharpoons Cl_2O_5 + 2\ CO_2$

(b) $N_2O_5 + SO_2 \rightleftharpoons N_2O_4 + SO_3$

(c) $N_2O + 2\ ClO_2 \rightleftharpoons N_2O_5 + Cl_2$

(d) $2\ PH_3 + 3\ COF_2 \rightleftharpoons 2\ PF_3 + 3\ CH_2O$

11. Molybdenum (III) chloride, $MoCl_3$, is a yellow solid. When dissolved in water the molybdenum ions reacts reversibly with chloride ions to form hexachloromolybdenum (III) ions, which are blue.

$$\underset{\text{yellow}}{Mo^{3+}(aq)} + 6\ Cl^-(aq) \rightleftharpoons \underset{\text{blue}}{MoCl_6^{3-}(aq)} + 33\ kJ$$

As a result of the equilibrium the solution appears green (a mix of the yellow/ blue colour). Which of the following procedures will cause the green solution to turn blue?

I. Bubbling hydrogen chloride gas through the solution
II. Adding a solution of silver nitrate
III. Heating the solution
IV. Adding a suitable catalyst to increase the forward reaction rate

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

12. Arsenine (AsH_3) can be produced by the hydrogen reduction of tetraarsenic hexoxide. The reaction is exothermic and reversible.

$$3\ As_4O_6\ (s) + 36\ H_2\ (g) \rightleftharpoons 12\ AsH_3\ (g) + 18\ H_2O\ (g) + 125\ kJ$$

Which of the following conditions will increase the rate of the forward reaction?

I. Continuously adding hydrogen at high pressure
II. Maintaining a high temperature
III. Continuously cooling the mixture
IV. Continuously removing the arsenine

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

13. Which of the following ions does not have a conjugate base?

(a) CH_3COO^-
(b) HCO_3^-
(c) NH_4^+
(d) H_3O^+

14. Water can act as an acid or as a base. In which of the following reactions is water acting as an acid?

I. $H_2O + NH_4^+ \rightarrow H_3O^+ + NH_3$
II. $H_2O + HPO_4^{2-} \rightarrow OH^- + H_2PO_4^-$
III. $H_2O + SO_4^{2-} \rightarrow OH^- + HSO_4^-$
IV. $H_2O + HCl \rightarrow H_3O^+ + Cl^-$

(a) I only
(b) I and IV only
(c) II and III only
(d) IV only

15. Three of the following solutions have a pH of very close to 7. One has a pH of close to 4. Which is the pH 4 solution?

(a) ammonium ethanoate NH_4CH_3COO

(b) ammonium chloride NH_4Cl

(c) ammonium phosphate $(NH_4)_3PO_4$

(d) sodium bromide NaBr

16. In which of the following species does platinum have the lowest oxidation number?

(a) H_2PtCl_6

(b) $NaPtCl_4$

(c) Pt_2O_3

(d) $PtCr_2O_7$

17. Which of the following metals can be produced by bubbling hydrogen gas through a solution of its chloride?

(a) Sodium

(b) Iron

(c) Copper

(d) Zinc

18. Sally, Cina and John design an electrochemical cell consisting of two half cells joined by a salt bridge. Each of the half cells consists of a metal rod placed in a 1 mol L^{-1} solution of its nitrate. Which of the following pairs of half cells will produce the highest theoretical voltage (emf)?

(a) Aluminium in aluminium nitrate solution and iron in iron (II) nitrate solution

(b) Copper in copper (II) nitrate solution and zinc in zinc nitrate solution

(c) Lead in lead (II) nitrate solution and manganese in manganese (II) nitrate solution

(d) Silver in silver nitrate solution and tin in tin (II) nitrate solution

19. Nina makes a description of a substance:
"Species X will oxidise quickly in moist air if its surface is scratched. Further oxidation of X is prevented by an oxide layer that forms on its surface?" Which is species X?

(a) A sheet of galvanised iron (completely covered with a thin layer of zinc)

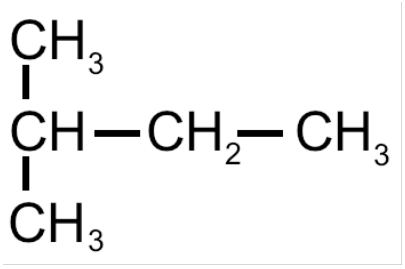
(b) A sheet of aluminium

(c) A sheet of copper

(d) A 'tin' can (iron coated completely with a thin layer of tin)

20. The following structural diagram represents a saturated hydrocarbon. What is the correct (IUPAC) name for the hydrocarbon?

(a) Dimethyl propane
(b) Ethyl propane
(c) Methyl butane
(d) Pentane



21. Which of the following chlorinated propenes has two geometric (cis-trans) forms?

I. 1 – chloropropene
II. 2 – chloropropene
III. 3 – chloropropene

(a) I only
(b) I and III only
(c) II and III only
(d) III only

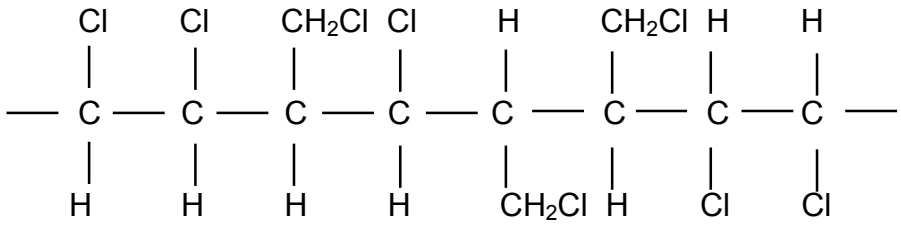
22. Which of the following substances is least likely to react with an acidified solution of sodium permanganate?

(a) 1 – propanol
(b) 2 – propanol
(c) Propanal
(d) Propanone

23. One mole of an organic compound, containing only carbon, hydrogen and oxygen, required five moles of oxygen for complete combustion. Four moles of carbon dioxide and four moles of water were produced. What was the formula of the compound?

(a) C_2H_4O
(b) $C_4H_4O_2$
(c) C_4H_8O
(d) $C_4H_8O_2$

24. The following diagram represents part of a polymer chain in a plastic.



This polymer could be produced from

I. cis – 1,3 – dichloropropene
II. trans – 1,3 – dichloropropene
III. 1,2 - dichloropropane
IV. 1,2 - dichloropropene

(a) I or II only
(b) II or IV only
(c) II or IV only
(d) I, II or IV only

25. Which of the following substances will not act as a surfactant (soap / detergent)?

(a) Ammonium stearate (stearate ion = $C_{17}H_{35}COO^-$)
(b) Magnesium stearate (stearate ion = $C_{17}H_{35}COO^-$)
(c) Hexadecylammonium sulfate (hexadecylammonium ion = $C_{16}H_{33}NH_3^+$)
(d) Sodium hexadecylsulfonate (hexadecylsulfonate ion = $C_{16}H_{33}SO_3^-$)

END OF SECTION 1

SECTION 2 12 questions (70 marks 35 %) Answer ALL questions in the spaces provided.

Spare pages are included at the end of this booklet. They can be used for planning your answers 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 a spare page to continue an answer, indicate in the original answer space where the answer is continued, i.e. state the page number. Write the number of the question(s) that you are continuing to answer at the top of the page.

Suggested time for this section is 70 minutes.

Question 26 **(4 marks)**

Write equations for the reactions that occurs in each of the following procedures.
If no reaction occurs, write 'no reaction'. 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^+], **molecules** [for example NH_3] or **solids** [example $CaCO_3$].

(a) Chlorine gas is bubbled through an acidified solution of hydrogen peroxide. (2 marks)

Equation

_____

_____

(b) Solid aluminium oxide is added to nitric acid solution. (2 marks)

Equation

_____

_____

Question 27 **(4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any

- colours
- precipitates
- gases produced

If no change is observed, you should state this.

(a) Methanol is added to a solution of propanoic acid in the presence of a catalyst. (2 marks)

Observation_____

_____

_____

_____

(b) Copper wire is placed in a solution of nickel chloride. (2 marks)

Observation_____

_____

_____

_____

Question 28 **(4 marks)**

Anions such as hydrogencarbonate (HCO_3^-) and hydrogenphosphate (HPO_4^{2-}) are able to act as bases in aqueous solutions. However, in water hydrogensulfate ion (HSO_4^-) does not act as a base.

Explain these facts. Include equations.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 29 **(4 marks)**

Write the IUPAC name, or draw the structural formula (including all atoms) respectively, for each of the following organic compounds.

NAME	STRUCTURAL FORMULA
A secondary alcohol	
	$CH_3CH(CH_3)COCH_3$
cis – 2 – pentene	

Question 30 **(6 marks)**

(a) Andrew's group measures the pH of a 0.1 $molL^{-1}$ ethanoic acid solution and finds the pH to be 2.89. Upon adding some 0.1 $molL^{-1}$ sodium ethanoate solution, the pH changes to 4.69. Explain why the pH changes. Use an equation in your answer. (2 marks)

_____

_____

_____

_____

EQUATION:

(b) Upon adding the sodium ethanoate solution, Andrew's group make a buffer. Explain the buffer capacity of the resulting solution. (1 mark)

_____

_____

_____

_____

(c) The group adds a few drops of dilute sodium hydroxide to the buffer. Explain, with reference to Le Chatelier's Principle, the effect of adding the sodium hydroxide to the buffer. Use an equation in your explanation. (3 marks)

_____

_____

_____

_____

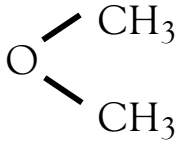
_____

_____

EQUATION:

Question 31 **(4 marks)**

Dimethyl ether (CH_3OCH_3) has the structure.



Would you expect dimethyl ether to be soluble in water **(Yes/ No)**? _____
Explain your reasoning. You should add to the above diagram and refer to the diagram in your explanation.

_____

_____

_____

_____

_____

Question 32 **(6 marks)**

For each species in the following table:

* Draw the structural diagram, representing all valence shell electron pairs as dots (∶) or as dashes (—), and
* Indicate the shape (name or sketch) of the species

Species	**Structural diagram** (showing all valence shell electron pairs)	**Shape** (name or sketch)
Methylidyne phosphane HCP		
Sulfite ion SO_3^{2-}		

Question 33 **(9 marks)**

Phosphoric acid (H_3PO_4) is a triprotic acid.

(a) List all the anions present (in order of decreasing concentration) in a solution of phosphoric acid (excluding the hydroxide ion).
Write equations to show how you determined this. (3 marks)

_____

_____

_____

_____

_____

_____

_____

Of these ions, which is the most basic? _____

(b) Phosphoric acid is a weak acid. However, it becomes stronger when heated. (3 marks)
Explain why.

(c) Is propanoic acid (CH_3CH_2COOH) a polyprotic acid? _____
Explain why. (3 marks)

Question 34 **(4 marks)**

Dodecane can be catalytically cracked to produce lower molecular weight hydrocarbons.

$$C_{12}H_{26}\,(g) + 725\ kJ \rightleftharpoons C_8H_{18}\,(g) + C_4H_8\,(g)$$

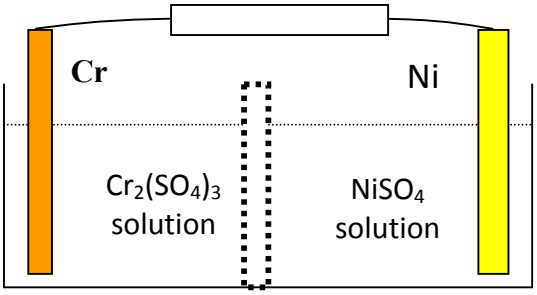
In a laboratory experiment a reaction vessel, whose volume can be changed, contains an equilibrium mixture of all three gases, and 40% of the mixture is dodecane.
The volume is now decreased. The temperature is kept constant.

(a) How does this volume decrease affect the two reaction rates? Explain why. (2 marks)

(b) How does this volume decrease affect the ratio of products to reactants once the equilibrium is reestablished? Explain. (2 marks)

Question 35 **(10 marks)**

The following diagram represents an electrochemical cell based on chromium and nickel. A porous barrier separates the two half cells but allows ions to migrate between them.



The temperature of the system is at 25°C and the electrolytes have a concentration of 1 $molL^{-1}$.

(a) Write the equation for the reaction that occurs. (2 marks)

_____

(b) On the diagram, label the electrode that is the anode. (1 mark)

(c) Draw an arrow in the box provided to show the direction of the electron flow in the wire. (1 mark)

(d) What is the maximum theoretical emf (voltage) that could be generated? (1 mark)

_____

(e) Which metal cations (positive metal ions) will migrate through the porous barrier? (1 mark)

_____

(f) List TWO changes that will be observed in the cell over time. (2 marks)

_____

_____

_____

_____

(g) What will be observed if the porous barrier is removed and the solutions become mixed? (2 marks)

_____

_____

_____

Question 36 **(8 marks)**

The inside surface of copper frying pans used for cooking foods such as eggs can develop a black coating due to the formation of copper (II) sulfide. These blackened pans can be restored by adding an electrolytic solution such as sodium chloride and placing aluminium foil in the pan. The aluminium foil is held down so that it makes good contact with the copper surface. This method does not remove any of the copper from the pan. The two half reactions that occur are:

$$CuS\ (s) + 2\,e^- \rightarrow Cu + S^{2-}$$

$$Al\ (s) \rightarrow Al^{3+} + 3\,e^-$$

The by-product of this process is aluminium sulfide.

(a) Write an equation for the net redox reaction. (2 marks)

(b) Why must the aluminium foil be touching the copper surface? (2 marks)

(d) A frying pan has a 0.0525 g coating of copper sulfide. What mass of aluminium sulfide will be formed as the copper is restored? (4 marks)

Question 37 **(7 marks)**

Explain each of the following facts about reactions between acids and metals. Include equations.

(a) Zinc reacts with hydrochloric acid, but copper does not. (4 marks)

(b) Copper reacts with concentrated nitric acid and a gas is produced. The gas is not hydrogen. (3 marks)

End of Section 2

Section 3 Extended answer 40% (80 Marks)

This section contains seven (7) questions Answer ALL questions in the spaces provided.

Spare pages are included at the end of this booklet. They can be used for planning your answers 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 a spare page to continue an answer, indicate in the original answer space where the answer is continued, i.e. state the page number. Write the number of the question(s) that you are continuing to answer at the top of the page.

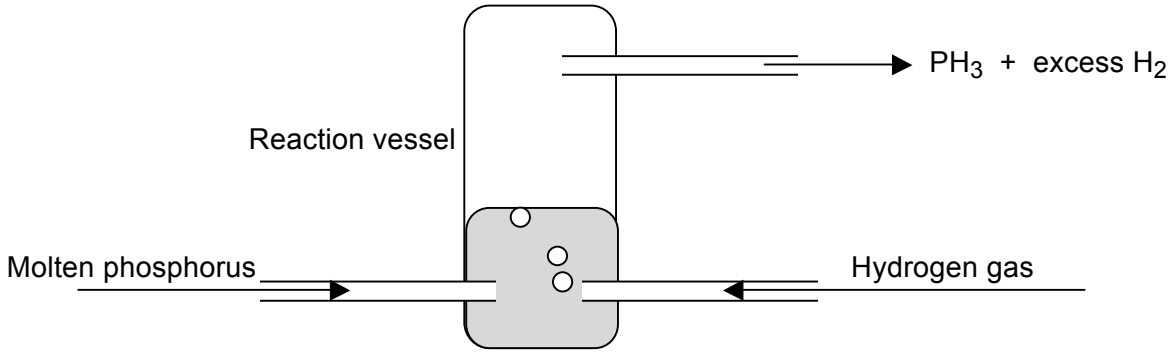
Suggested time for this section is 70 minutes.

Question 38 (12 marks)

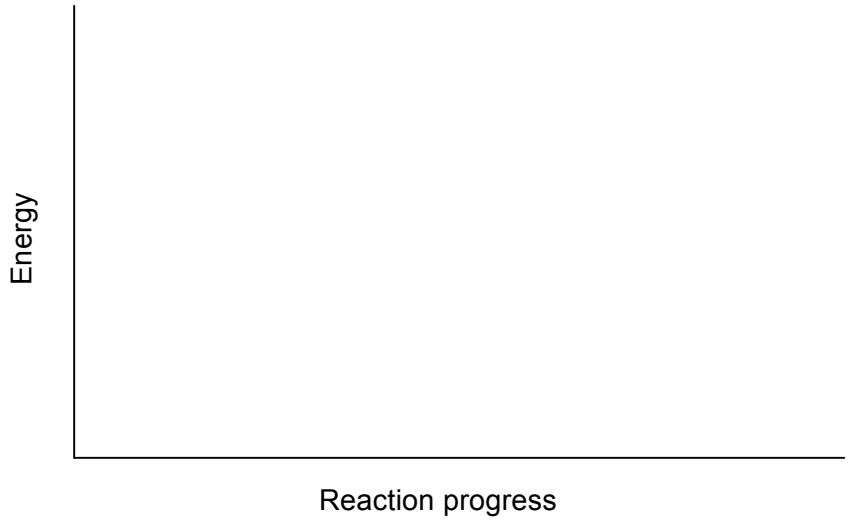
Phosphine (PH_3) is a gas that could be produced by bubbling hydrogen gas through molten phosphorus.

The reaction is reversible P_4 (l) + 6 H_2 (g) ⇌ 4 PH_3 (g) + 33 kJ

Activation energy = + 66 kJ



(a) Draw a labelled energy profile graph to represent the process. (4 marks)
Clearly label the reactants, products, activation energy and enthalpy change.



(b) Would a high, moderate, or a low temperature be used in the process? Explain why. (3 marks)

(c) If the process is only 70.0% efficient, what mass of phosphorus would be needed to produce 4500 kL of phosphine (stored at 3.55 atmospheres pressure in cylinders at 30.0 ^{o}C)? (5 marks)

Question 39 **(10 marks)**

A swimming pool holds 250 m^3 of water. The owner tests the water and finds its hydroxide ion concentration, $[OH^-]$, is 5.55×10^{-5} mol L^{-1}. (1 m^3 = 1000 L)

(a) What is the pH of the pool water? (4 marks)

(b) Thinking the pH is too low, the owner adds to the water 3.00 kg of caustic soda (NaOH). The water pump ensures that the caustic soda dissolves and becomes evenly mixed in the pool.

What is the new pH of the water? (6 marks)

Question 40 **(12 marks)**

An organic compound containing only **carbon, hydrogen, oxygen and nitrogen** is analysed by the following steps:

- 1.473 g is burned in oxygen, converting the carbon to 2.515 g of carbon dioxide and the hydrogen to 1.158 g of water.
- A separate 1.26 g sample is treated so that the nitrogen is oxidised. It produces 0.5623 g of nitrogen dioxide (NO_2).

(a) What is the empirical formula of the compound? (9 marks)

- When vaporised,1.473 g of the compound occupies 313 mL at 76 kPa pressure and 127 ^oC.

(b) What is its molecular formula? (3 marks)

Question 41 **(10 marks)**

A student wanting to produce ethyl oxalate prepares a mixture of 50.0 g of oxalic acid (HOOCCOOH) and 50.0 g of ethanol (CH_3CH_2OH) in a boiling flask. She adds a few drops of concentrated sulfuric acid and boils the mixture for about an hour.

The equation for the reaction is

$$HOOCCOOH + 2\ CH_3CH_2OH \rightarrow CH_3CH_2OOCCOOCH_2CH_3 + 2\ H_2O$$

(a) Determine the limiting reactant. (4 marks)

(b) What mass of ethyl oxalate would be produced? (4 marks)

(c) After the mixture has cooled she adds 100 mL of water. Soon she observes that there are two layers of liquid in the flask. Why were there two liquid layers? (2 marks)

_____

_____

_____

_____

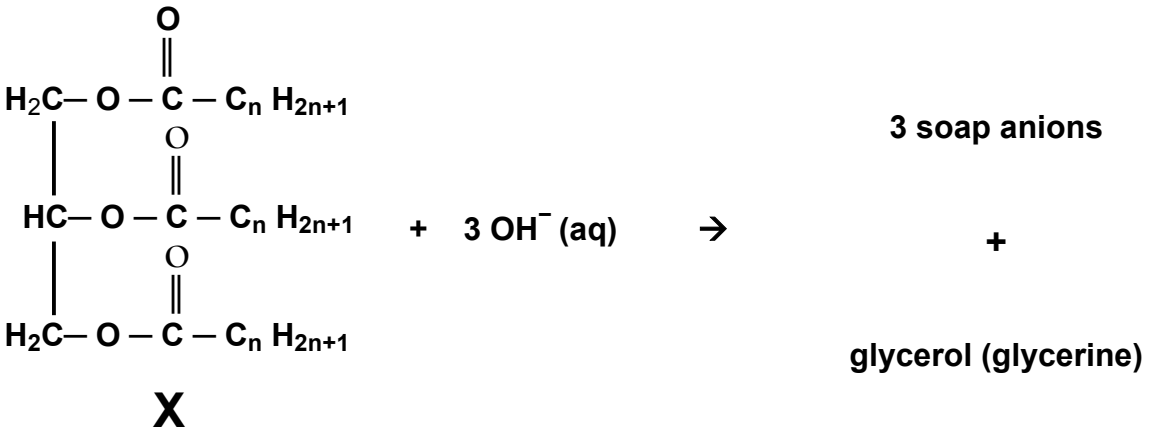
_____

_____

_____

Question 42 **(11 marks)**

Sophie prepares some soap in the laboratory. Soap can be produced by the alkaline hydrolysis of animal fat. The structure of the fat can be represented by the formula, **X**, below. The number n is large, usually about 16. The equation represents the hydrolysis reaction. Soap is simply the sodium salt of the anion.



X

(a) What is another name for this process of producing soap? (1 mark)

_____

(b) What is the general name for compounds represented by the letter **X**? (1 mark)

_____

(c) Why does the hydrocarbon chain (C_nH_{2n+1}) have to be long? (2 marks)

_____

_____

_____

(e) When n = 16 in the formula C_nH_{2n+1} the molecular mass of the fat is 848.54.
What mass of sodium hydroxide solid is needed to convert 1 tonne of fat into soap?
[1 tonne = 1000 kg] (4 marks)

(f) The hydrocarbon chain represented by the formula C_nH_{2n+1} is a saturated alkyl group. Health professionals are encouraging us to use vegetable oils that are unsaturated or polyunsaturated.

(i) Show that the chain represented by the formula C_nH_{2n+1} is saturated. (2 marks)
Include a diagram of a chain that has 4 carbon atoms.

(ii) We are also being encouraged to use less trans-unsaturated oils. (1 mark)
Draw a structure that represents a trans-unsaturated hydrocarbon alkyl group.

Question 43 **(15 marks)**

A jar containing a pale pink powder is labelled *commercial grade manganese (II) sulfate $MnSO_4$*. Davis needs to know its percentage by mass purity. He decides to analyse it by utilising the reaction between hydrogen peroxide and manganese ion. The manganese ions are converted into a black precipitate of manganese (III) oxide. The black oxide quickly settles to the bottom of the conical flask. The equation for the reaction is

$$H_2O_2 + 2\,Mn^{2+} + H_2O \rightarrow Mn_2O_3 + 4\,H^+$$

The end point is taken to be when the final drop of hydrogen peroxide no longer produced a black precipitate.

Davis dissolved 2.00 g sample of the impure manganese (II) sulfate in water in a 100 mL volumetric flask. He then pipetted 25.0 mL of this solution and diluted it to 250 mL in another volumetric flask. Next, he titrated 20.0 mL aliquots of the diluted manganese (II) sulfate solution against 0.002211 mol L^{-1} hydrogen peroxide solution. The average titre required was 46.55 mL.

(a) How many moles of hydrogen peroxide were consumed in an average titration? (2 marks)

(b) How many moles of manganese (II) ions were oxidised in an average titration? (2 marks)

(c) How many moles of manganese (II) sulfate were present in the impure sample? (3 marks)

(d) What was the percentage purity of the commercial manganese (II) sulfate? (3 marks)

(e) The chemist could also analyse the impure manganese sulfate by dissolving a sample in water, then adding excess hydrogen peroxide solution and finally performing a titration to determine the excess hydrogen peroxide.

(i) Suggest what reagent he could use for the titration.
Include an equation to justify your answer. (4 marks)

(ii) Suggest how the end point of this titration would be determined. (1 mark)

Question 44 **(10 marks)**

The labels have fallen off four organic reagent bottles in a laboratory. The bottles each contain **cyclohexene, butanoic acid, hexan-2-one** and **hexan-2-ol**. Due to the toxic nature of the fumes, students are not allowed to smell the fumes to identify the reagents. Using readily available laboratory equipment and chemicals, describe a procedure you could use to identify the unknowns. Explain your answer in terms of the physical/ chemical properties of each of the four liquids. Include all relevant balanced chemical equations with structural formulae.

Your answer should include four (4) paragraphs and be 1 to 1.5 pages in length.

End of Paper

Spare pages for working out or for continuing answers to previous questions