



STRIVE FOR THE HIGHEST

Western Australian Certificate of Education

Mock Examination, 2011

Question/Answer Booklet

NAME

CHEMISTRY

Stage 3

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.

OFFICE USE ONLY

	MARK	TOTAL	%
Section 1		50	
Section 2		70	
Section 3		80	

TOTAL		200	
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Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	25	50	25	25
Section Two: Short answer	12	12	60	70	35
Section Three: Extended answer	6	6	70	80	40
					100

Instructions to candidates

- 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.
- 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.

- When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise.
- 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.
- 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 %)

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 a different number of protons?
 - (a) carbocation 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.

SEE NEXT PAGE

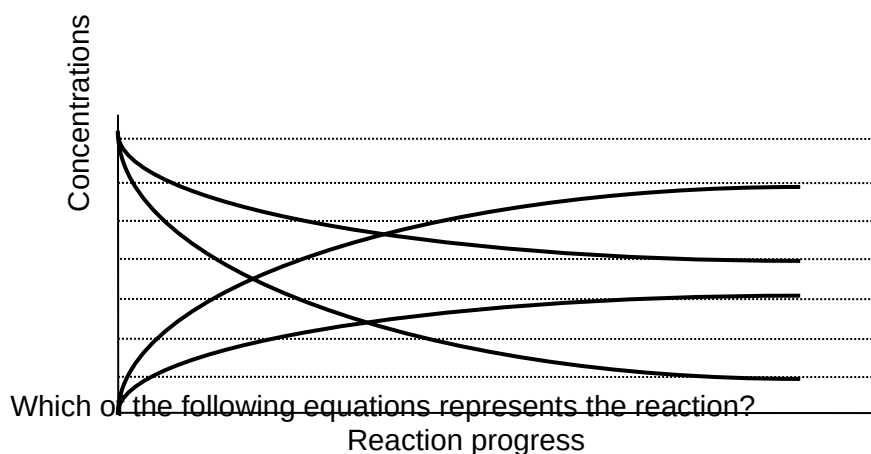
6. What is the shape of a water molecule?
- (a) Linear
 - (b) Bent (V-shape)
 - (c) Pyramidal
 - (d) Tetrahedral
7. Which type of bonding is **NOT** present in solid hydrogen chloride?
- (a) covalent
 - (b) dipole – dipole
 - (c) dispersion force
 - (d) hydrogen bonding
8. The boiling points of a family of trihalomethanes (CHX_3) are listed below.

Tetrafluoromethane	CHF_3	$-89\text{ }^\circ\text{C}$
Tetrachloromethane	CHCl_3	$61\text{ }^\circ\text{C}$
Tetrabromomethane	CHBr_3	$150\text{ }^\circ\text{C}$
Tetraiodomethane	CHI_3	$330\text{ }^\circ\text{C}$

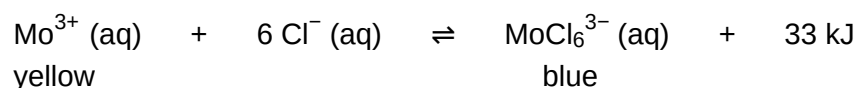
The increase in boiling points moving down the list is due to an increase in the strength of:

- (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) silver sulfate Ag_2SO_4
 - (b) calcium phosphate $\text{Ca}_3(\text{PO}_4)_2$
 - (c) barium hydroxide $\text{Ba}(\text{OH})_2$
 - (d) zinc carbonate ZnCO_3

10. Two gases are mixed 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.



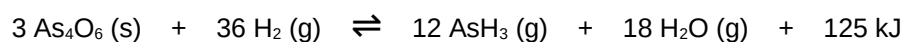
- (a) $\text{Cl}_2\text{O}_7 + 2 \text{CO} \rightleftharpoons \text{Cl}_2\text{O}_5 + 2 \text{CO}_2$
- (b) $\text{N}_2\text{O}_5 + \text{SO}_2 \rightleftharpoons \text{N}_2\text{O}_4 + \text{SO}_3$
- (c) $\text{N}_2\text{O} + 2 \text{ClO}_2 \rightleftharpoons \text{N}_2\text{O}_5 + \text{Cl}_2$
- (d) $2 \text{PH}_3 + 3 \text{COF}_2 \rightleftharpoons 2 \text{PF}_3 + 3 \text{CH}_2\text{O}$
11. Molybdenum(III) chloride, MoCl_3 , is a yellow solid. When dissolved in water the molybdenum ions react reversibly with chloride ions to form hexachloromolybdenum(III) ions, which are blue.



As a result of the equilibrium the solution appears yellow. Which of the following procedures will cause the yellow 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) II, III and IV only
- (b) I and IV only
- (c) II and III only
- (d) I only

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



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

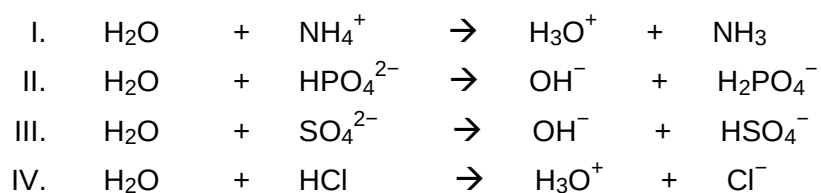
- I. Continuously adding hydrogen at high pressure
- II. Maintaining a high temperature
- III. Continuously cooling the mixture
- IV. Continuously removing the arsenine

- (a) I and II
- (b) II and III
- (c) I and III
- (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?

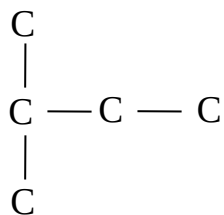


- (a) I only
- (b) I and IV only
- (c) II and III only
- (d) IV only

15. Three of the following solutions have a pH very close to 7. One has a pH close to 4. Which solution has a pH close to 4?
- | | | |
|-----|--------------------|------------------------------------|
| (a) | ammonium acetate | $\text{NH}_4\text{CH}_3\text{COO}$ |
| (b) | ammonium chloride | NH_4Cl |
| (c) | ammonium phosphate | $(\text{NH}_4)_3\text{PO}_4$ |
| (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) Copper
(b) Iron
(c) Sodium
(d) Zinc
18. A group of students is designing 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 voltage (emf)?
- (a) Lead in lead (II) nitrate solution and manganese in manganese (II) nitrate solution
(b) Copper in copper (II) nitrate solution and zinc in zinc nitrate solution
(c) Aluminium in aluminium nitrate solution and iron in iron (II) nitrate solution
(d) Silver in silver nitrate solution and tin in tin (II) nitrate solution
19. Which of the following will oxidise quickly in moist air if its surface is scratched, but further oxidation is prevented by the oxide layer that has formed on the surface?
- (a) A sheet of galvanised (completely coated with a thin layer of zinc) iron
(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

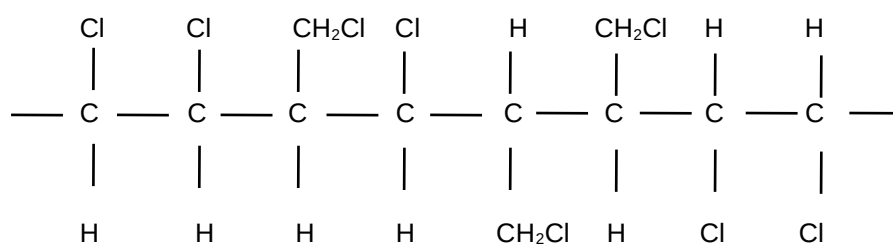
22. Which of the following substances is least likely to react with an acidified solution of sodium permanganate?

- (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) $\text{C}_2\text{H}_4\text{O}$
- (b) $\text{C}_4\text{H}_4\text{O}_2$
- (c) $\text{C}_4\text{H}_8\text{O}$
- (d) $\text{C}_4\text{H}_8\text{O}_2$

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



Which of the following could this polymer be produced from?

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

- (a) I or II only
- (b) II or IV only
- (c) III 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 = $\text{C}_{17}\text{H}_{35}\text{COO}^-$)
- (b) Magnesium stearate (stearate ion = $\text{C}_{17}\text{H}_{35}\text{COO}^-$)
- (c) Hexadecylammonium sulfate (hexadecylammonium ion = $\text{C}_{16}\text{H}_{33}\text{NH}_3^+$)
- (d) Sodium hexadecylsulfonate (hexadecylsulfonate ion = $\text{C}_{16}\text{H}_{33}\text{SO}_3^-$)

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.
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Suggested time for this section is 60 minutes.

Question 26**(4 marks)**

Write net ionic equations for any reactions that occur in each of the following procedures showing only those species consumed and any new species formed.

If no reaction occurs, write 'no reaction'.

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

- (b) Solid aluminium oxide is added to nitric acid (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) Hydrogen peroxide is added to an acidified solution of iron (II) sulfate. (2 marks)
- Observation

SEE NEXT PAGE

(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 the hydrogensulfate ion (HSO_4^-) does not act as a base.

Explain these facts. Use equations to support your answer.

Question 29**(4 marks)**

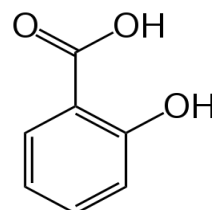
Complete the following table by writing the IUPAC name, or drawing a structural formula, for the following organic compounds.

IUPAC Name	Structural Formula
A secondary alcohol	
	$\text{CH}_3\text{CH}(\text{CH}_3)\text{COCH}_3$
cis – 2 – pentene	
	$\text{CH}_3\text{CH}_2\text{CHBrCOOH}$

Question 30**(6 marks)**

Salicylic acid is a colorless crystalline organic acid which is widely used in organic synthesis and functions as a plant hormone. In addition to being a compound that is chemically similar to but not identical to the active component of aspirin (*acetylsalicylic acid*), it is probably best known for its use in anti-acne treatments.

The structure of salicylic acid is shown at the right.



In an aqueous environment, salicylic acid ionises and exists in equilibrium with the salicylate ion.

(a) Write the equation for the reaction between salicylic acid and water.

(1 mark)

(b) What is a buffer?

(1 mark)

(c) Show, using equations and the principles of equilibrium, how a solution of salicylic acid and the salicylate ion may behave as a buffer.

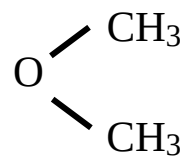
(4 marks)

SEE NEXT PAGE

Question 31

(4 marks)

Dimethyl ether (CH_3OCH_3) has the structure shown at the right.



Would you expect dimethyl ether to be soluble in water? _____

With the aid of the above diagram, explain your reasoning.

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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)
Methyldyne phosphane HCP		
Sulfite ion SO_3^{2-}		

Question 33**(9 marks)**

Phosphoric acid (H_3PO_4) is a polyprotic acid.

- (a) List all the anions present (in order of decreasing concentration) in a solution of phosphoric acid (excluding hydroxide ions).

Write equations to show how you determined this.

(3 marks)

Of the ions you have listed, which is the most basic? _____

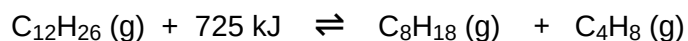
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- (c) Phosphoric acid is a weak acid. However, it becomes stronger when heated. (3 marks)
Explain why.

- (c) Is propanoic acid ($\text{CH}_3\text{CH}_2\text{COOH}$) a polyprotic acid? _____ (3 marks)
Explain.

Question 34**(4 marks)**

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



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.

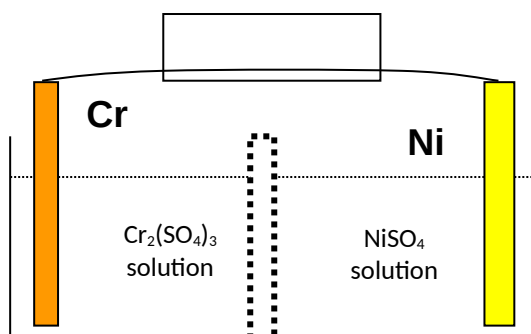
The volume is now decreased and the temperature is kept constant.

- (a) Explain how this volume decrease would affect the two reaction rates.

- (b) Explain how this volume decrease would affect the percentage composition of the mixture.

Question 35**(10 marks)**

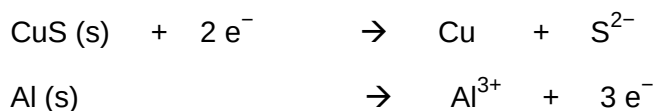
The following diagram represents an electrochemical cell based on chromium and nickel. A porous barrier separates the two half cells but allows ions to migrate between them.



- (a) Write the equation for the reaction that occurs. (2 marks)
- _____
- (b) On the diagram, label the anode. (1 mark)
- (c) In the box provided, draw an arrow to show the direction of the electron flow in the wire. (1 mark)
- (d) What emf (voltage) will be generated? (Assume 1 mol L^{-1} concentrations.) (1 mark)
- _____
- (e) Which metal cations will migrate through the porous barrier? (1 mark)
- _____
- (f) List TWO changes that will be observed. (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:



The by-product of this process is aluminium sulfide.

- (a) Write an equation for the net redox reaction. (1 mark)

- (b) Why must the aluminium foil be touching the copper surface? (1 mark)

- (c) In terms of electrochemistry explain how the process works?

(3 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? (3 marks)

Question 37**(7 marks)**

By referring to the Table of Standard Reduction Potentials, 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. (3 marks)

End of Section 2**SEE NEXT PAGE**

Section 3**Extended answer****40% (80 Marks)****This section contains six (6) 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.

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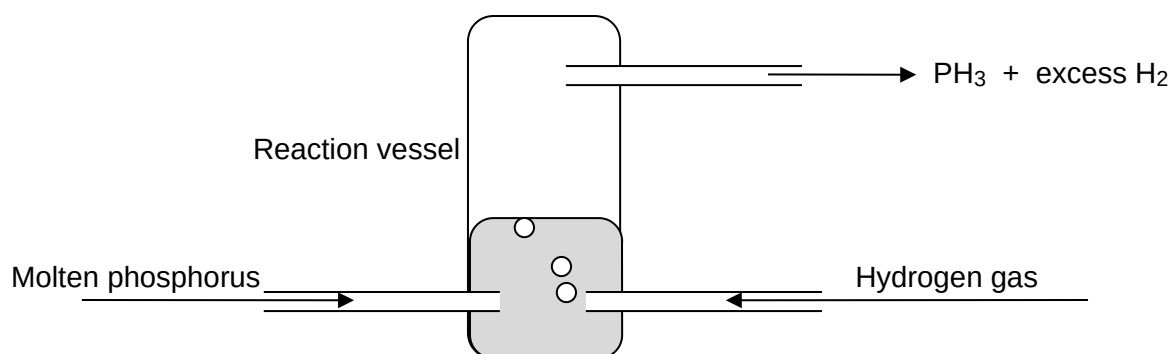
Suggested time for this section is 70 minutes.

Question 38**(15 marks)**

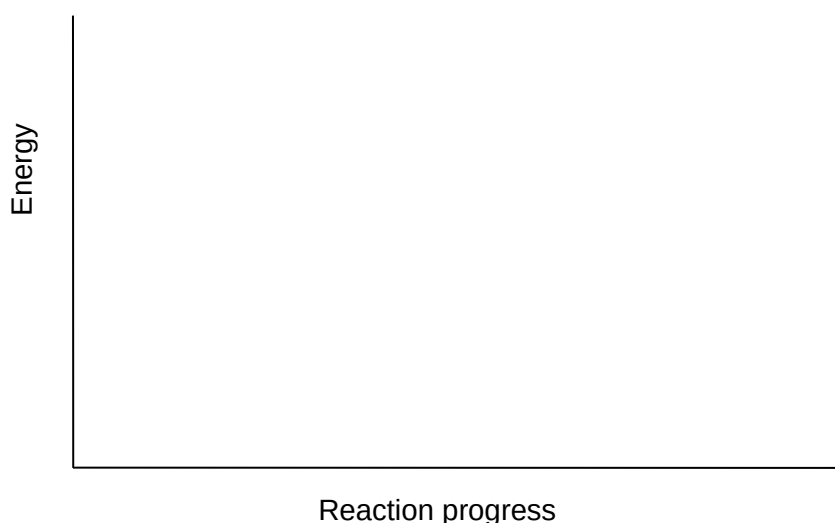
Phosphine (PH_3) is a gas that could be produced by bubbling hydrogen gas through molten phosphorus.

The reaction is reversible $\text{P}_4(\text{l}) + 6 \text{H}_2(\text{g}) \rightleftharpoons 4 \text{PH}_3(\text{g}) + 33 \text{ kJ}$

Activation energy = 66 kJ



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

**SEE NEXT PAGE**

- (b) Explain whether a high temperature or a low temperature, would be used in the process?
(3 marks)

- (c) Explain whether a high pressure or a low pressure, would be used in the process?
(3 marks)

- (d) If the process is only 70.0% efficient what mass of phosphorus would be needed to produce 4500 kL of phosphine, stored in cylinders at a pressure of 3.55 atmospheres and a temperature of 30.0 °C?

(5 marks)

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Question 39

(10 marks)

A swimming pool holds 250 cubic metres of water. The owner tests the water and finds that its hydroxide ion concentration, $[\text{OH}^-]$, is $5.55 \times 10^{-5} \text{ mol L}^{-1}$. (1 cubic metre = 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)

[illegible]

Question 40

(13 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.
- Another 1.473 g is treated so that the nitrogen is oxidized to 0.6573 g of nitrogen dioxide (NO_2).
- When vaporized 1.473 g of the compound occupies 156.5 mL at 304 kPa pressure and 127 °C.

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

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

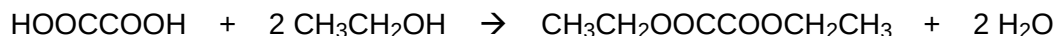
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Question 41**(13 marks)**

A student wanting to produce ethyl oxalate (ethyl ethandioate) prepares a mixture of 50.0 g of oxalic acid (ethandioic acid) (HOCCOOH) and 50.0 g of alcohol (CH₃CH₂OH) 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



- (a) What role does the sulfuric acid play in the reaction? (1 mark)

- (b) Determine the limiting reactant (reagent). (5 marks)

- (c) What mass of ethyl oxalate (ethyl ethandioate) would be produced? (3 marks)

(d) After the mixture has cooled she adds 100 mL of water. Soon she observes that there are two layers of liquid in the flask

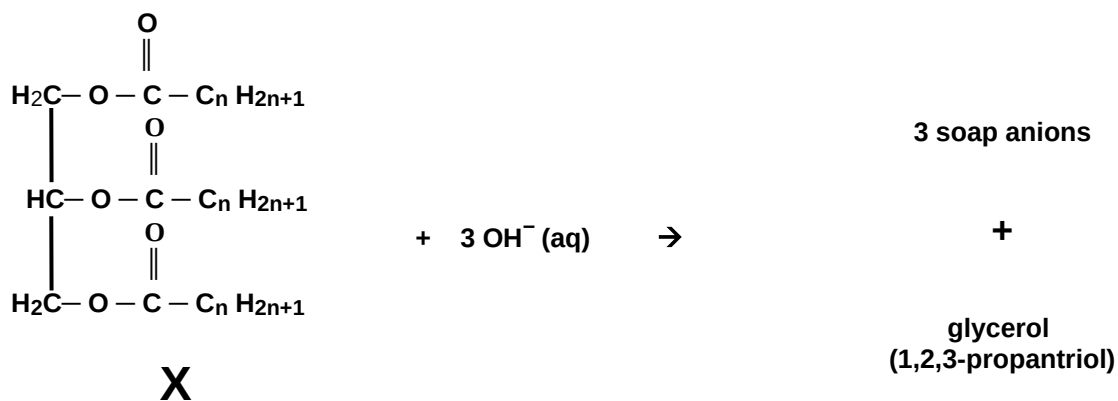
(i) Suggest a reason for adding water. (2 marks)

(ii) Explain why there were two liquid layers? (2 marks)

Question 42

(14 marks)

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.



- (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) Write a formula for soap, substituting numbers for the letter n. (1 mark)

- (d) Why does the hydrocarbon chain (C_nH_{2n+1}) have to be long? (4 mark)
Include a diagram.

- (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 is needed to convert 1 tonne of fat into soap?
[1 tonne = 1000 kg]

(4 mark)

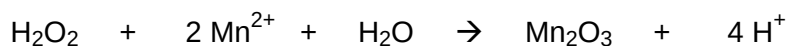
- (f) The hydrocarbon chain represented by the formula C_nH_{2n+1} is a saturated alkyl group. Health professionals are encouraging people to use vegetable oils that are unsaturated or polyunsaturated.

- (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) People 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 . A chemist needs to know its percentage purity by mass. She decides to analyse it by utilizing the reaction between hydrogen peroxide and manganese(II) ions. 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



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

The chemist dissolved a 2.000 g sample of the impure manganese(II) sulfate in water in a 100 mL volumetric flask. She then pipetted 25.00 mL of this solution and diluted it to 250 mL in another volumetric flask.

Next, she titrated 20.00 mL aliquots of the diluted manganese (II) sulfate solution against $0.002211 \text{ mol L}^{-1}$ 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 by mass of the commercial manganese(II) sulfate?

(3 marks)

(e) The chemist could also have analysed the impure manganese(II) 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 a reagent she 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)

End of paper

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

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