2009

HSC Half-Yearly Examination

Chemistry

General Instructions
Reading time – 5 minutes
Working time – 1.5 hours

Write using blue or black pen
Draw diagrams using pencil
Approved calculators may be used
Write your student number on each section of this booklet

Total marks 65
This examination has two parts, Part A and Part B.
Part A – 10 marks
Attempt Questions 1 – 10.
Allow about 15 minutes for this part.

Part B – 55 marks
Attempt Questions 11 – 19.
Allow about 1 hour and 15 minutes for this part.

Teacher-in-charge: Mr Geerling

Task Weighting: 20%

Chemistry 2009

Multiple choice answer sheet

This sheet may be separated from the rest of the paper for your convenience.

Part A

1. A ⬭ B ⬭ C ⬭ D ⬭
2. A ⬭ B ⬭ C ⬭ D ⬭
3. A ⬭ B ⬭ C ⬭ D ⬭
4. A ⬭ B ⬭ C ⬭ D ⬭
5. A ⬭ B ⬭ C ⬭ D ⬭
6. A ⬭ B ⬭ C ⬭ D ⬭
7. A ⬭ B ⬭ C ⬭ D ⬭
8. A ⬭ B ⬭ C ⬭ D ⬭
9. A ⬭ B ⬭ C ⬭ D ⬭
10. A ⬭ B ⬭ C ⬭ D ⬭

TOTAL _____ / 10

Part A.

10 marks

Attempt questions 1 - 10.

Allow about 15 minutes for this part.

Record your answers on the separate multiple-choice answer sheet that is on the back of the exam title page. You may DETACH this page for your convenience. Ensure your student number is written on it.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

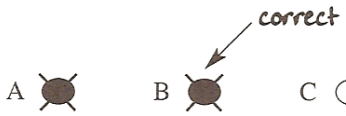
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ~~correct~~ and drawing an arrow as follows.



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1. Identify the name for the compound represented by the condensed structural formula.

$$CH_3 = CH - \underset{\displaystyle CH_3}{\overset{\displaystyle |}{CH}} - CH_3$$

(A) 2-methyl-3-butene
(B) 1-pentene
(C) 3-methyl-1-butene
(D) methylbutyne

2. Despite the similar properties between ethane and ethene, ethene is used more readily in industry than ethane because:

(A) the –C-C- bond is much more reactive than the –C=C- bond
(B) the –C-C- bond is much less reactive than the –C=C- bond
(C) ethane is less soluble in water than ethene
(D) ethane has stronger dispersion forces than ethene

3. Which of the following pairs would form a buffer solution?

(A) H_2SO_4 / HSO_4^-
(B) OH^- / H_2O
(C) HCOOH / $HCOO^-$
(D) HNO_3 / NO_3^-

4. During esterification it is necessary to use refluxing apparatus. The most correct scientific reason for refluxing in the esterification process is:

(A) It allows the reaction to be carried out at a lower temperature and prevents the loss of volatile substances.
(B) It allows the reaction to be carried out at a higher temperature and prevents the loss of volatile substances.
(C) It allows the reaction to be carried out at a lower temperature and prevents the loss of sulfuric acid.
(D) It allows the reaction to be carried out at a higher temperature and prevents the loss of water.

5. Consider the following statements.

1. *Acids are substances which produce hydrogen ions in aqueous solution.*
2. *Acids are proton donors.*
3. *Bases are substances which ionise in water to produce hydroxide ions.*
4. *Bases are proton acceptors.*

Which statements, if any, are consistent with the Arrhenius theory of acids and bases?

(A) none
(B) 1 only
(C) 2 and 4
(D) 1 and 3

6. Consider the following reaction between marble chips (calcium carbonate) and dilute hydrochloric acid:

$$CaCO_{3(s)} + 2H^+_{(aq)} \rightarrow Ca^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

What volume of carbon dioxide will be released at 25°C and 100 kPa when 50.00 g of powdered marble chips are added to 750 mL of 0.525 mol/L hydrochloric acid?

(A) 4.88 L
(B) 9.76 L
(C) 11.3 L
(D) 12.4 L

7. The hydrogen carbonate ion, HCO_3^-, may act as an acid or a base in aqueous solution. In which of the following equations below is it acting as an acid?

(A) $HCO_3^-{}_{(aq)} + H_2O_{(l)} \Leftrightarrow H_2CO_{3\,(aq)} + OH^-_{(aq)}$
(B) $HCO_3^-{}_{(aq)} + H_3O^+_{(aq)} \Leftrightarrow H_2CO_{3aq)} + H_2O_{(g)}$
(C) $HCO_3^-{}_{(aq)} + H_2O_{(l)} \Leftrightarrow CO_3^{2-}{}_{(aq)} + H_3O^+_{(aq)}$
(D) $HCO_3^-{}_{(aq)} + OH^-_{(aq)} \Leftrightarrow CO_{2(aq)} + 2OH^-_{(aq)}$

8. In a chemistry laboratory two reagent bottles are labelled 1 $mol.L^{-1}$ sulfuric acid and 10.0 $mol.L^{-1}$ ethanoic acid. Based on this information and your knowledge of acids, which of the following statements uses correct terminology?

(A) The ethanoic acid is more concentrated than the sulfuric acid.
(B) The ethanoic acid is stronger than the sulfuric acid.
(C) The sulfuric acid solution is weaker than the ethanoic acid solution.
(D) The ethanoic acid solution is more dilute than the sulfuric acid solution

9. The formula of the ester *ethyl propanoate* is :-

(A) $CH_3CH_2COOCH_2CH_3$.
(B) $CH_3COOCH_2CH_2H_3$.
(C) $CH_3COOCH_2CH_3$.
(D) $CH_3CH_2CH_2OOCCH_2CH_3$

10. Which of the following lower atmosphere pollutant gases is produced directly by the smelting of mineral ores?

(A) carbon monoxide
(B) nitrogen dioxide
(C) ozone
(D) sulfur dioxide

Part B.

55 marks

Attempt questions 11 – 19.
Read the whole of each question before commencing it.
Answer the questions in the spaces provided.
Show full working for questions requiring calculations.
Allow about 1 hour and 15 minutes for this part.

Question 11.

When ammonia gas is reacted with oxygen gas at a constant temperature and pressure, nitrogen monoxide gas and water vapour are produced. In a closed system, an equilibrium situation is eventually established. The reaction is exothermic.

(a) Write an equation to represent this equilibrium reaction. States are to be included. 1M

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(b) Complete the table to predict the effect of the changes listed. 3M

Change imposed	***Effect on yield of nitrogen monoxide***
Increase concentration of oxygen gas	
Addition of a catalyst	
Increase in the pressure of the system	

(c) State Le Chatelier's principle. 2M

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(d) State the collision theory. 1M

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Question 11 continues on the following page.

(e) Sketch an energy profile diagram to represent this equilibrium system **without** the presence of a catalyst.
On the SAME set of axes AND in a different colour, sketch another energy profile diagram to show the profile that would be expected **in** the presence of a **catalyst**.
Include a key to clearly classify the identity of each profile diagram. 3M

Question 12.

25 mL of 0.08 mol/L hydrochloric acid is mixed with 30 mL of 0.05 mol/L sodium hydroxide.
Calculate the pH of the resultant solution. 4M

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Question 13.

Coal fired power stations can contribute to the problem of acid rain if the coal burnt contains sulfur impurities.
A recent media report quoted a politician who said that converting from coal to methane in electricity generation would eliminate the production of acid rain.

Assess the accuracy of this statement, including appropriate chemical equations. 4M

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Question 14.

Analyse the relationship between the structure of polyethylene and polyvinyl chloride, and a use of each.

6M

Question 15.

When 2.5 L of hydrogen bromide gas and 1.6 L of ammonia gas (measured at 25ºC and 100 kPa) are mixed, ammonium bromide is formed as a white solid.

(a) Write an equation for the reaction described. 1M

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(b) Demonstrate that this is an acid-base reaction using Bronsted-Lowry definitions. 2M

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Question 16.

You performed a first hand investigation to identify the pH of a range of salt solutions.

(a) Complete the table to identify a salt that produces an acidic solution and a salt that produces a basic solution. 2M

Nature of the salt solution	Example of a salt
Acidic	
Basic	
Neutral	Sodium chloride

(b) From the table, select a salt that forms an acidic solution OR basic solution, and justify its classification. Include an equation to illustrate your answer. 2M

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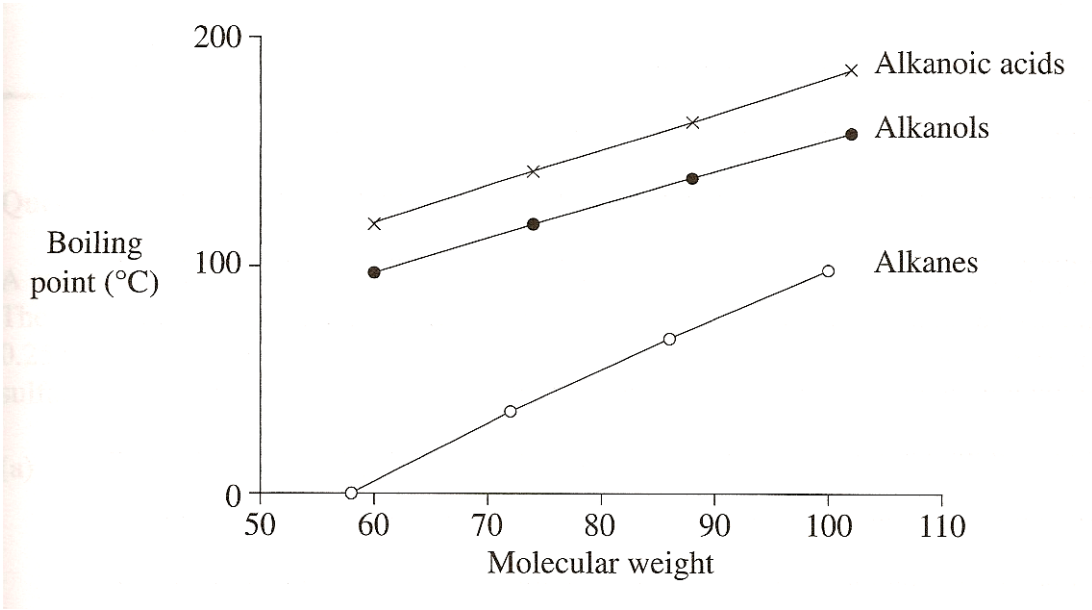
Question 17.

Explain the trends in boiling points shown in the graph. 4M



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Question 18.

Polyvinyl alcohol is a water-soluble addition polymer used in adhesives and paints. The monomer is vinyl alcohol (ethanol) with the structure:

$$CH_2=CHOH$$

(a) Construct a structural formula for a segment of the polymer polyvinyl alcohol that is comprised of 3 monomer units. 2M

(b) Describe how bromine water can be used to distinguish between a solution of the monomer and a solution of the polymer. 5M

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Question 19.

A tin of commercial rust remover is labelled as containing *'highly concentrated phosphoric acid (H_3PO_4)'.*

A student performed an investigation to determine the exact concentration of the phosphoric acid. 10.0 mL of the rust remover was diluted to 200 mL in a prepared volumetric flask. A 20.0 mL aliquot of this diluted acid was then placed into a prepared conical flask, a few drops of a suitable indicator were added and then the diluted acid was titrated against a previously standardised 0.93 mol/L sodium hydroxide solution. This was repeated four times.

The following table records the volumes of sodium hydroxide required to reach the endpoint.

Run number	Volume of sodium hydroxide added (mL)
1	22.6
2	21.4
3	21.2
4	21.3

(a) Make a scientific diagram of the piece of equipment used to measure out the 20.0 mL aliquot of diluted acid. 1M

(b) Outline how the volumetric flask should have been prepared prior to use. 1M

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(c) Explain how the conical flask should have been prepared prior to use. 2M

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(d) Outline a suitable method to use to standardise the sodium hydroxide solution. 2M

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(e) Calculate the concentration in grams per litre (g/L) of phosphoric acid in the tin of rust remover. 4M

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(f) Methyl orange is NOT a suitable indicator for use in this titration. Justify this statement. 3M

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Marking Guidelines HY Exam 2009
Year 12 CHEMISTRY

Part A – multiple choice.

1. C
2. B
3. C
4. B
5. B
6. A
7. C
8. A
9. A
10. D

Part B.

11 a.

Marking criteria	*Marks*
Presents a correct equilibrium equation that includes the states of each species [$4NH_{3(g)} + 5O_{2(g)} \leftrightarrow 4NO_{(g)} + 6H_2O_{(g)}$]	1

11 b.

Marking criteria	*Marks*
Identifies the effect on yield of nitrogen monoxide for all three of the outlined changes [*increases; no effect ; decreases*] for the equation presented in 11a.	3
Identifies the effect on yield of nitrogen monoxide for two of the outlined changes	2
Identifies the effect on yield of nitrogen monoxide for one of the outlined changes	1

11 c.

Marking criteria	*Marks*
Presents a thorough and precise statement of Le Chatelier's Principle [*ideal answer would be - when a system at equilibrium is disturbed, the system will alter to counterbalance the change .....AND a new equilibrium will form*]	2
Presents a generalised statement of Le Chatelier's Principle	1

11 d.

Marking criteria	*Marks*
Outlines the key concept of the collision theory [*for a reaction to occur there must be collisions between the reacting species(these collisions must also occur with sufficient energy and with correct orientation of reactant species to be successful)*]	1

11 e.

Marking criteria	*Marks*
Energy profile diagram that is presented covers all 6 points as outlined: (1) Diagram shows an exothermic profile (2) One line is sketched to show the profile without a catalyst (3) Another line is sketched to show the profile with a catalyst (4) A key that clearly identifies each line is provided (5) The vertical axis is appropriately labelled [*eg. energy*] (6) The horizontal axis is appropriately labelled [*eg. time; reaction pathway*]	3
The energy profile presented is that of an exothermic reaction and has two lines showing the activation energy 'hump' lower in the profile with the addition of a catalyst.	2
The energy profile diagram presented is that of an endothermic reaction OR is an exothermic profile with no activation energy 'hump'.	1

12.

Marking criteria	*Marks*
Calculates the pH correctly as 2.0 with full and appropriate working (7 steps/processes) (1) Calculates moles of HCl [$2 X 10^{-3}$ *mol*] (2) Calculates moles of NaOH [1.5 X 10^{-3} *mol*] (3) Determines mole ratio of HCl to NaOH (may be implied by a balanced equation) [*1 : 1*] (4) Determines which reactant is in excess [HCl] (5) Determines by how many moles in excess [$5 X 10^{-4}$ *mol*] (6) Determines the new volume of the solution [*55 mL*] (7) Determines the final pH [*2.04 = 2.0 since number of significant figures in data is equal to number of decimal places in answer*]	4
Correctly complete 5 or 6 of the seven steps outlined above	3
Correctly complete 3 or 4 of the seven steps outlined above	2
Correctly complete 1 or 2 of the seven steps outlined above	1

13.

Marking criteria	*Marks*
Makes a judgement about the accuracy of one or two of the statements AND Outlines the production of acid rain from two sources other than sulfur impurities in coal AND Includes two correct relevant chemical equations	4
Makes a judgement about the accuracy of one or two of the statements AND Outlines the production of acid rain from one source other than sulfur impurities in coal AND Includes one correct relevant chemical equation	3
Outlines the production of acid rain from two sources other than sulfur impurities in coal OR Outlines the production of acid rain from one source other than sulfur impurities in coal and supports this with a correct, relevant chemical equations	2
Response contains one correct statement about the production of acid rain other than from sulfur impurities in coal	1

14.

Marking criteria	*Marks*
Analyses both polyethylene (PE) and polyvinyl chloride (PVC) by covering the following: Identifies and describes the structure of both PVC and PE **AND** Relates ONE/TWO properties based on the structure to an identified use of both PVC and PE	5 - 6
Identifies the structure of PE **AND** Identifies the structure of PVC **AND** Identifies a use of PE **AND** Identifies a use of PVC	4
THREE of the four points outlines above for 4	3 - 4
Identifies the structure of PE and/or PVC	1 - 2

15 a.

Marking criteria	*Marks*
Writes a correct chemical equation [$HBr + NH_3 \leftrightarrow NH_4^+ + Br^-$]	1

15 b.

Marking criteria	*Marks*
States that HBr is a B-L acid because it acts as a proton donor [*forming Br-]* **AND** States that NH_3 is a B-L base because it acts as a proton acceptor [*forming NH_4^+]*	2
Identifies that HBr is acting as an acid **and** that NH_3 is acting as a base	1

16 a.

Marking criteria	*Marks*
Identifies a salt that produces an acidic solution [*eg. ammonium nitrate*] **AND** Identifies a salt that produces a basic solution [*eg. sodium ethanoate*]	2
Identifies a salt that produces an acidic solution **OR** Identifies a salt that produces a basic solution	1

16 b.

Marking criteria	*Marks*
Writes a chemical equation that shows the production of surplus H^+ ions or surplus OH^- ions **AND** Gives reasons as to why this happens	2
Justifies their classification based on SA+WB = acidic OR WA+SB = basic.	1

17.

Marking criteria	*Marks*
(1) Outlines the relationship between molecular weight and boiling point. evident in all 3 lines AND relates this to increasing dispersion forces (2) Outlines the relationship between the boiling point and type of compound at any given molecular weight (3) Relates this to the predominant type of intermolecular bonding present →alkanes = dispersion forces; →alkanols = hydrogen bonding' →alkanoic acids = greater hydrogen bonds AND explains why the different types/strengths of intermolecular forces arise (polar vs non-polar need to be mentioned)	4
As for 4 marks answer BUT has missed ONE or TWO of the key facts	2 - 3
Outlines the relationship between molecular weight and boiling point	1

18 a.

Marking criteria	*Marks*
Correct structural formula with three units of the monomer joined appropriately and all covalent bonds shown	2
Monomers are correctly arranged into an addition polymer but there is an error (eg. only two monomer units shown; not all covalent bonds shown; condensed structural formulae used)	1

18 b.

Marking criteria	*Marks*
Outlines a procedure for using bromine water to distinguish between unsaturated and saturated carbon compounds that is logical, scientifically correct, and demonstrates that the variable of UV light has been controlled and that two or more other variables are also controlled (eg. intensity and duration of mixing, volumes of each reactant) **AND** Outlines full observations regarding the colour of bromine water (rather than deductions about rate/extent of reactivity) when added to EACH solution being tested. Specifically - • Vinyl alcohol –tan bromine water will rapidly undergo a colour change to colourless • Poly vinyl alcohol - tan bromine water will remain tan (in absence of UV light) **AND** Answer must specifically relate to vinyl alcohol/ polyvinyl alcohol rather than other unsaturated/saturated carbon compounds	5
(1) # Outlines a procedure for using bromine water to distinguish between unsaturated and saturated carbon compounds that is thorough (see marking criteria for 5 marks) AND # Outlines full observations regarding the colour of bromine water (rather than deductions) when added to ONE of the solutions (see marking criteria for 5 marks) **OR** (2) # Identifies some aspects of an appropriate method AND # Outlines full observations regarding the colour of bromine water (rather than deductions) when added to EACH of the solutions	4
(1) Identifies that bromine water will react readily/react rapidly/change colour/decolourise with vinyl alcohol AND/OR Identifies that bromine water will not react/react slowly/not change colour with poly vinyl alcohol	2 - 3
(2) Compares vinyl alcohol and poly vinyl alcohol for the same reaction indicator	
Makes a correct statement about the use of bromine water to distinguish between the reactivity of unsaturated and saturated carbon compounds (eg. bromine water is tan in colour)	1

NOTE: Avoid presenting extra 'information' that is not needed (and has the potential to be incorrect or contradictory). For example, in this specific scenario, bromine water will readily dissolve into the water-soluble polymer since both chemicals are polar in nature. Thus, two immiscible layers will NOT form.

19 a.

Marking criteria	*Marks*
Scientific diagram of a pipette [showing correct shape, open ends, etched mark] done in pencil	1

19 b.

Marking criteria	*Marks*
Outlines that the volumetric flask should be rinsed with distilled water several times with the rinsings being discarded each time	1

19 c.

Marking criteria	*Marks*
Outlines the cause and effect relationship by linking the use of distilled water for the final rinsing of the conical flask to the fact that distilled water will NOT alter the number of moles of reactant in the aliquot	2
Outlines that a conical flask should be rinsed with distilled water several times	1

19 d.

Marking criteria	*Marks*
Response covers the following four points:- (1) Preparation of an acidic primary standard of known concentration (2) Identifies a suitable acidic primary standard (eg oxalic acid; potassium phthalate) (3) Titration of the sodium hydroxide solution against a suitable primary standard (4) Calculation of the concentration of the sodium hydroxide	2
Response covers point (3) from above	1

19 e.

Marking criteria	*Marks*
* Correctly calculates the concentration of the	4

rust remover as 6.5 X 10^2 g/L of phosphoric acid The following four steps need to be covered :- (1) correctly balanced chemical equation (2) calculates the average titre as 21.3 mL (3) calculates the moles of phosphoric acid in the aliquot as 6.603 … X 10^{-3} mol (4) calculates the g/L of phosphoric acid (nb. this final step requires several sub-steps to be correctly completed) * ALL calculations are well set out, logical and fully detailed.	
Covers THREE of the four steps	3
Covers TWO of the steps	2
Covers ONE of the steps	1

19 f.

Marking criteria	***Marks***
(1) Identifies that methyl orange changes colour in the acidic pH range (specifically, 3.1 – 4.4) [ie. titration end point] (2) Identifies that the neutralised solution will have a pH of approximately 9 [ie. titration equivalence point] AND justifies the basic pH at equivalence point by stating that phosphoric acid is weak and sodium hydroxide is strong. (3) States (or implies) that the end point for this titration will not equal its equivalence point	3
(1) Identifies that methyl orange (**changes colour**) in the acidic pH range AND (2) Identifies, incorrectly, that the neutralised solution will have a pH of approximately 7 AND justifies this, incorrectly, by stating that phosphoric acid is strong (but correctly that sodium hydroxide is strong) **OR** (1) Identifies, correctly, that phosphoric acid is weak and that sodium hydroxide is strong [and hence the equivalence point does not match the end point] BUT (2) does not state that methyl orange **changes colour** in an acidic pH range	2
Identifies that methyl orange (**changes colour**) in the acidic pH range **OR** Identifies that the end point for this titration will not equal its equivalence point	1

HAHS Half-Yearly Examination

2009 – Chemistry

Exemplar answers

1	2	3	4	5	6	7	8	9	10
C	B	C	B	B	A	C	A	A	D

Question 11.
When ammonia gas is reacted with oxygen gas at a constant temperature and pressure, nitrogen monoxide gas and water vapour are produced. In a closed system, an equilibrium situation is eventually established. The reaction is exothermic.

(a) Write an equation to represent this equilibrium reaction. States are to be included. 1M

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ ✓ 1

(b) Complete the table to predict the effect of the changes listed. 3M

Change imposed	*Effect on yield of nitrogen monoxide*
Increase concentration of oxygen gas	increase ✓
Addition of a catalyst	~~increase~~ no effect; only reaction rate increases ✓
Increase in the pressure of the system	decrease ✓

3

(b) Complete the table to predict the effect of the changes listed. 3M

Change imposed	*Effect on yield of nitrogen monoxide*
Increase concentration of oxygen gas	increase. ✓
Addition of a catalyst	no effect. ✓
Increase in the pressure of the system	decrease. ✓

3

(c) State Le Chatelier's principle. 2M

In an equilibrium ✓ if a change is made which disturbs the equilibrium (ie change in temperature, pressure, concentration) the equilibrium will respond by shifting to counteract ✓ the change and establish a new equilibrium excellent answer

2

(e) Sketch an energy profile diagram to represent this equilibrium system **without** the presence of a catalyst.
On the SAME set of axes AND in a different colour, sketch another energy profile diagram to show the profile that would be expected **in** the presence of a **catalyst**.
Include a key to clearly classify the identity of each profile diagram. 3M

Energy profile

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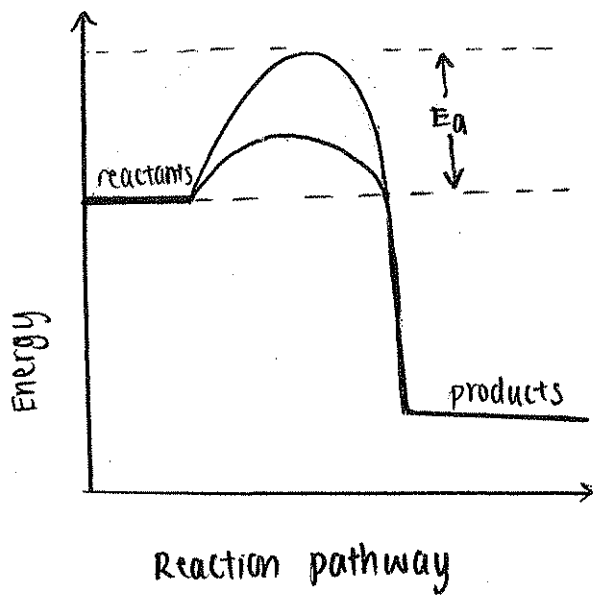

— without catalyst
— with catalyst

Question 12.
25 mL of 0.08 mol/L hydrochloric acid is mixed with 30 mL of 0.05 mol/L sodium hydroxide.
Calculate the pH of the resultant solution. 4M

4

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

$n_{HCl} = CV = 0.08 \times 0.025 = 2 \times 10^{-3}$ ✓ $n_{NaOH} = CV = 0.05 \times 0.03 = 1.5 \times 10^{-3}$

$HCl : NaOH \rightarrow 1:1 \rightarrow 2\times10^{-3} : 1.5\times10^{-3}$ ✓

$1.3 : 1$ ∴ HCl is in excess

no of mol of HCl in excess $= 2\times10^{-3} - 1.5\times10^{-3} = 5\times10^{-4}$ ✓

Volume of acid + base $= 0.025 + 0.03 = 0.055$ ✓

Final conc. $= C = \frac{n}{V} = \frac{5\times10^{-4}}{0.055}$

$= 9.090909091 \times 10^{-3}$

$HCl \rightarrow H^+ + Cl$

$pH = -\log [H^+]$

$= -\log 9.090909091\times10^{-3}$ ✓

$= 2.04$

excellent!

Question 13.

Coal fired power stations can contribute to the problem of acid rain if the coal burnt contains sulfur impurities.

A recent media report quoted a politician who said that converting from coal to methane in electricity generation would eliminate the production of acid rain.

Assess the accuracy of this statement, including appropriate chemical equations. 4M

This statement is incorrect as Acid rain is not only formed from SO_2 but also NO_2 and CO_2 that react with moisture in the air. By converting coal to methane in electricity generation, the generation of electricity itself will emit CO_2 into the air and contribute to the formation of acid rain $\Rightarrow CO_{2(g)} + H_2O_{(g)} \rightarrow H_2CO_{3(aq)}$. Also the high temperatures required to produce electricity, which are usually over 1300° will cause Nitrogen and oxygen in the air to react and produce NO, $N_{2(g)} + O_{2(g)} \rightarrow 2NO$. The NO will then slowly react with O_2 in the air $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ to produce NO_2 which will in turn react with moisture to produce Nitric acid $NO_{2(g)} + H_2O_{(g)} \rightarrow HNO_{3(aq)}$. Therefore the politician is incorrect as with the method he chooses to appy to reduce SO_2 in the formation of acid rain, will lead to the formation of CO_2 and NO_2 instead which will also contribute to the formation of acid rain.

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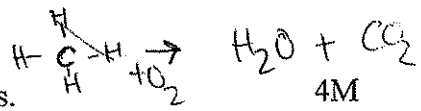


Assess the accuracy of this statement, including appropriate chemical equations. 4M

This is an inaccurate statement, as the burning of methane produces water vapour and carbon dioxide gas:

$$CH_{4(g)} + 2O_{2(g)} \rightarrow 2H_2O_{(g)} + CO_{2(g)}$$

This carbon dioxide can dissolve in rain to produce carbonic acid:

$$CO_{2(g)} + H_2O_{(l)} \rightarrow H_2CO_{3(l)}$$

This is a process that already occurs naturally, giving rain a slightly acidic pH. By greatly increasing the volume of CO_2 in the atmosphere, there is a risk that more may dissolve into rain and cause acid raid. Therefore, the statement is wrong.

3

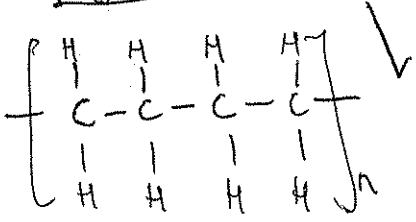
Question 14.

Analyse the relationship between the structure of polyethylene and polyvinyl chloride, and a use of each. 6M

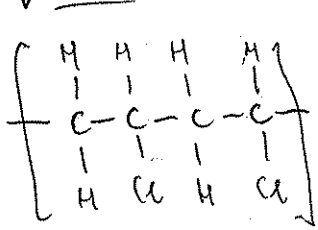
- Both polyethene and PVC are addition polymers with the same basic main chain of carbons
- They are different in that polyethylene is only has a hydrogen side chains whereas PVC has the bulky halogen, Cl side chain
- The bulky side chain in PVC makes it more rigid than polyethene as the side chain restrict the movement of the PVC chains
- Due to the extremely large size of the both chains they are both water proof/ impermeable to water as water is a polar molecule and hence cannot interact with it
- polyvinyl chloride exists only as a linear chain whereas depending on how polyethylene is produced it could be HDPE or LDPE
- HDPE has a low degree of chain branching and hence high reg regions of crystallinity as well as cross-linking accounting for its stiffness and opaque colour
- Due to the high regions of crystallinity in HDPE the dispersion forces are stronger between chains and hence it is very rigid and strong as well as being resistant to chemical attacks
- Due to this property it can be used for bottle caps, barrels, garbage bins
- LDPE on the other hand has a high degree of chain branching and hence low levels of crystallinity and is clear
- This makes LDPE more flexible as there are less dispersion forces due to the branches being further apart
- Hence it can be used for cling wrap due to its flexibility but at the same time fairly strong, water-proof and resistant to most chemicals
- The rigidness of PVC due to its structure allows it to be used for cold water pipes once a plasticiser has been added to decrease brittleness

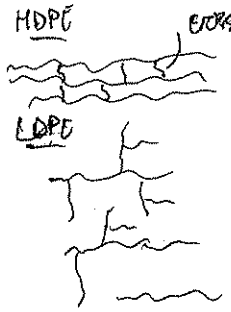
(6)

polyethene



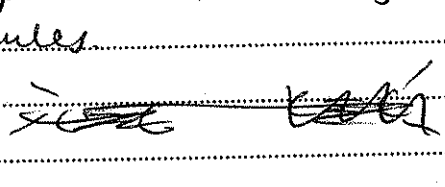
PVC





polyvinyl chloride also decompose under sunlight & heat. Hence the underground usage of polyvinyl chloride for pipes is suitable.

Polyethylene is formed by the addition of ethylene molecules.



6

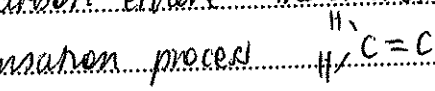
- Like vinyl chloride - ethylene has 2 carbon base except has H atom attached instead of a Cl atom.

- Low density polyethylene is used for cling wrap and garbage bags due to its flexible nature → unlike rigidity of PVC. → branched chains

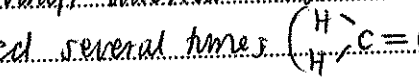
- High density polyethelene is used for bottle caps due to its rigidity & tightly packed chains.

Question 14.

Analyse the relationship between the structure of polyethylene and polyvinyl chloride, and a use of each. 6M

Polyethylene is a polymer that consists of repeating monomer units of the hydrocarbon ethene. The ethene's double bond is broken during the addition polymerisation process  The ends of the monomer unit consist of free radical that have an unpaired outershell electron that makes it very reactive. During propogation these ethene monomer units join to form a polymer → polyethene and the process is terminated. Low density polyethene (LDPE) consists of long and short chains of the hydrocarbon there resulting in the a branched chain that is not closely packed together. As the structure is not tightly packed this results in the effect of dispersion forces throughout the molecule decreasing therefore the LDPE has a fairly low melting and boiling point. This enables it to be moulded and heated and remoulded several time (ie thermoplastic). The plastic can therefore be fairly flexible and soft. It is used in plastic and garbage bags and flexible film wraps for its above properties.

6

Polyvinyl chloride consists of the monomer unit vinyl chloride or chloroethane repeated several times  ← chloroethane molecule. The structure can be made as a linear or unbranched molecule therefore the polymer is closely and densely packed together forming a rigid and crystalline structure with a high melting and boiling points. The plastic produced is therefore ingid and

Question 16.
You performed a first hand investigation to identify the pH of a range of salt solutions.

(a) Complete the table to identify a salt that produces an acidic solution and a salt that produces a basic solution. 2M

Nature of the salt solution	Example of a salt
Acidic	ammonium chloride
Basic	sodium acetate.
Neutral	Sodium chloride

(2)

Nature of the salt solution	Example of a salt
Acidic	Ammonium nitrate
Basic	sodium carbonate.
Neutral	Sodium chloride

(2)

(b) From the table, select a salt that forms an acidic solution OR basic solution, and justify its classification. Include an equation to illustrate your answer. 2M

ammonium chloride when dissolve in water will cause into ammonium & chloride ions

$NH_4Cl_{(aq)} \xrightarrow{H_2O_{(l)}} NH_{4(aq)}^+ + Cl^-_{(aq)}$ (2)

The ammonium ion will then react again with water forming ammonia and hydronium ions which will reduce the pH of the solution, hence it's a base salt

$NH_{4(aq)}^+ + H_2O_{(l)} \rightleftharpoons NH_{3(aq)} + H_3O^+_{(aq)}$

(b) From the table, select a salt that forms an acidic solution OR basic solution, and justify its classification. Include an equation to illustrate your answer. 2M

Sodium ethanoate $NaCH_3COO \rightarrow Na^+ + CH_3COO^-$

Na^+ cannot act as a B-L acid since it has no H^+ to donate, nor a B-L base because it can't accept any H^+. (2)

$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$

Since excess OH^- produced

∴ salt is basic.

additional weaker dispersion forces. However, there aren't as many intermolecular forces that can be experienced between molecules ⇒ thus their bp is higher than alkanes.

- Alkanes only experience weak dispersion forces with little energy (comparatively) required to break alkane molecules apart.
- Also as molecular weight increases, bp increases due to the presence of more molecules & thus more intermolecular forces to overcome.

The alkanes are non-polar hydrocarbons therefore they only have weak dispersion forces. As the molecular weight increase these dispersion forces increase therefore more energy is required to overcome the intermolecular forces of attraction resulting in higher boiling pts. (4)

The alkanols have higher boiling pts than the alkanes. This is due to the polar bonds that alkanols have (C-O and O-H). Alkanols are also able to form a hydrogen bond due to the presence of the hydroxyl group. Hydrogen bonding is the strongest form of intermolecular forces of attraction therefore much higher energy inputs are needed in order to overcome these forces of attraction which result in its higher boiling points in comparison to the alkanes.

The alkanoic acids have boiling points relatively higher than their corresponding alkanols. This is the result of its additional polar bond (C=O) and also the presence of the carboxyl group (COOH) enables alkanoic acids to form two hydrogen bonds with other ~~molecules of alk~~ alkanoic acids. This additional polar bond and hydrogen bond result in its higher ~~near~~ boiling pts ones both the alkanes and the alkanols.

All boiling pts increase as molecular weight increases due to more intermolecular forces of attraction between molecules resulting in higher energy input → higher boiling pts.

- As molecular weight increases, the dispersion forces between molecules also increases and so boiling pt. (b.p.) increases.
- Alkanes have much lower b.p. than alkanols and Alkanoic acids because they are non-polar molecules and only have weak dispersion forces between molecules whereas Alkanols and alkanoic acids are polar molecules and ~~have~~ can form strong hydrogen bonds which require more heat energy to break ∴ higher b.p. (4)

(b) Describe how bromine water can be used to distinguish between a solution of the monomer and a solution of the polymer. 5M

The bromine water can be used to differentiate between a solution of the monomer and a solution of the polymer because it will respond to the presence of a double bond. Two different test-tubes are needed, one of which is filled to a depth of 1cm with a solution of the monomer and the other to the depth of 1cm of a solution of the polymer (if identities are unknown but the monomer and polymer are in separate containers then fill one test-tube with solution from one container and fill the second test-tube with solution of the second container). This should be conducted in an environment absent of U.V light because U.V light promotes the photodecomposition of bromine water. 4 drops of the bromine water are added to each of the test tubes and the colours of each solution are noted. The test-tubes are then shaken to ensure thorough mixture chemicals. The test-tube holding a solution that is colourless is the one that holds the solution of the monomer because the double bond of the monomer caused it to react with the bromine water while the solution of the polymer should still be coloured yellow. (i.e yellow is colour of bromine water)

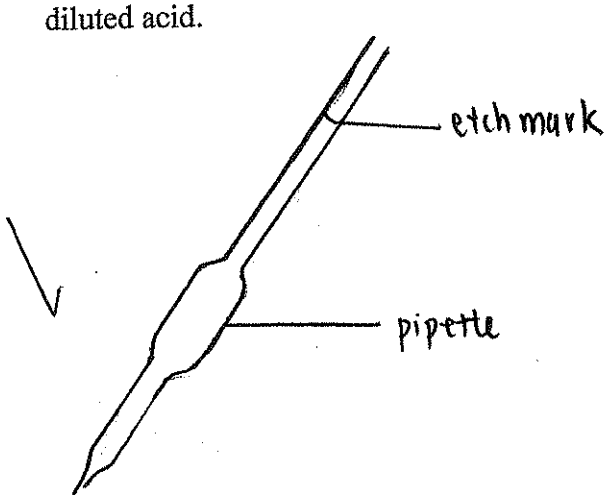
5 Great procedural description.

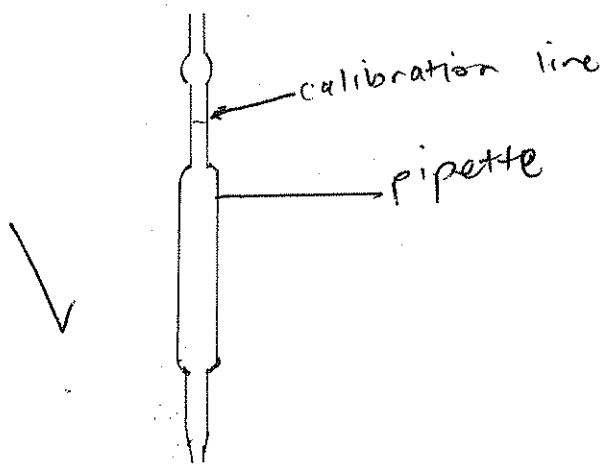
Question 19.

A tin of commercial rust remover is labelled as containing *'highly concentrated phosphoric acid (H_3PO_4)'*.

A student performed an investigation to determine the exact concentration of the phosphoric acid. 10.0 mL of the rust remover was diluted to 200 mL in a prepared volumetric flask. A 20.0 mL aliquot of this diluted acid was then placed into a prepared conical flask, a few drops of a suitable indicator were added and then the diluted acid was titrated against a previously standardised 0.93 mol/L sodium hydroxide solution. This was repeated four times.

(a) Make a scientific diagram of the piece of equipment used to measure out the 20.0 mL aliquot of diluted acid. 1M





leading to an inaccurate result. By rinsing with water only, the moles measured and placed into the flask would hold true to their calculated values.

2

not used as a primary standard: hydroscopic (absorbs moisture - reacts with CO_2 in atmosphere to form $NaHCO_3$

(d) Outline a suitable method to use to standardise the sodium hydroxide solution. pre prepared 2M

Sodium hydroxide solution can be titrated ~~against~~ with a primary standard such as oxalic acid. The solution of NaOH can be placed in the conical flask (prepared as outlined in (c)) and appropriate indicator added. The acid is used to fill the burette and titration conducted to find end point. Then the concentration of NaOH (aq) can be worked out by determining no. moles of acid required to react completely etc.

2

(d) Outline a suitable method to use to standardise the sodium hydroxide solution. 2M

Prepare an oxalic acid standard solution and determine the concentration. Titrate this with the sodium hydroxide solution several times and calculate the concentration of the NaOH solution from the result.

2

★★

(d) Outline a suitable method to use to standardise the sodium hydroxide solution. 2M

The sodium hydroxide solution may be standardised through volumetric analysis with a standard solution of benzoic acid. The benzoic acid is a suitable chemical for a standard solution as it is pure and free from absorbing moisture from the air. A titration procedure may be carried with a known concentration of benzoic acid and the ~~the~~ sodium hydroxide procedure. From this, the concentration of the sodium hydroxide solution may be calculated.

2

$C_{H_3PO_4} = n = \frac{6.603 \times 10^{-3}}{0.020} = 0.33015 \text{ mol/L}$

since diluted 10ml to 200ml, a dilution of 1:20.

ie. $[H_3PO_4] = 0.33015 \times 20$
$= 6.603 \text{ mol/L}$.

$M_{H_3PO_4} = Mn = (3.024 + 30.97 + 64)(6.603)$
$= 647g$

ie. 647g/L.

(f) Methyl orange is NOT a suitable indicator for use in this titration. Justify this statement. 3M

This titration involves the reaction between a weak base acid H_3PO_4 and a strong base NaOH. As the base is strong in this the reaction the equivalence point of this reaction will occur when at slightly above the pH of 7. The end point of an indicator therefore must be in a range that is greater than a pH of 7. Methyl orange has an end point at around 3.1 - 4.4 which would make it suitable while titrating a strong acid with a weak base. However with this reaction it will not change colour at the equivalence point therefore phenolphthalein which as an end point of around 8.2 - 10 would be a more suitable indicator to use.

2

(f) Methyl orange is NOT a suitable indicator for use in this titration. Justify this statement. 3M

A suitable indicator for this titration would have to be an indicator that produces an end point almost exactly where the equivalence point of the titration is. Methyl orange does not do this as its pH range is ~~3.1-4.~~ approximately 3.1 3.0 - 4.4. The equivalence point of this titration is ~~pH =~~ pH > 7 since the titration is of a weak acid (H_3PO_4) against a strong base (NaOH). Therefore if we used methyl orange, the indicator would reach its end point before the equivalence point. A more ~~suitable~~ suitable indicator would be, phenolphthalein as its pH range is 8.2 - 10.0, allowing an end point to be reached closer to the equivalence point.

2.

Wow!