| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

**Student Number**

**CHELTENHAM GIRLS HIGH SCHOOL**

# 2019

**HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION**

# CHEMISTRY

**General Instructions**

- Reading time – 5 minutes
- Working time – 3 hours
- Write using **black pen** only
- Draw diagrams using pencil
- Use the multiple-choice answer sheet provided
- NESA approved calculators may be used
- Write your Student Number at the top of this page and on the multiple-choice answer sheet write BOTH your number AND name.

**Total marks - 100**

This paper has two Sections A and B

**Section A – 20 marks**

- Attempt Questions 1-20
- Allow about 30 minutes for this part

**Section B – 80 marks**

- Attempt questions 21-37
- Allow about 2 hour and 30 minutes for this part

## SECTION A: MULTIPLE CHOICE QUESTIONS (20 MARKS)

**Attempt Questions 1 – 20**
**Allow about 30 minutes for this part**

Use the multiple-choice answer sheet for Questions 1 – 20

1. The concentration of lead in water collected from a city harbour is 1.5 ppm.
Which of the following is an equivalent concentration of lead?

(A) $0.0015\ gL^{-1}$
(B) $0.07\ mol\ L^{-1}$
(C) 1.5%(w/w)
(D) $15\ mgL^{-1}$

2. Consider the following reaction: $OBr^-(aq) + H2O(l) \rightleftharpoons HOBr(aq) + OH^-(aq)$

Which of the following represents an acid-base conjugate pair for this reaction?

(A) $OBr^-$ / H2O
(B) HOBr / $OH^-$
(C) $OBr^-$ / $OH^-$
(D) H2O / $OH^-$

3. A solution of NaOH is changed from a pH of 9.4 to a pH of 7.4. This means that the concentration of the $H_3O^+$ ions has

(A) increased by a factor of 2.
(B) decreased by a factor of 2.
(C) increased by a factor of 100.
(D) decreased by a factor of 100.

4. An aqueous solution was tested in the laboratory with various indicators. The results of the testing are displayed below.

| **Indicator used** | **Colour of solution with indicator added** |
|---|---|
| Phenolphthalein | Colourless |
| Methyl orange | Yellow |
| Bromothymol blue | Yellow |

From these results, it is possible to conclude that the solution

(A) is highly acidic.
(B) is highly alkaline.
(C) is slightly acidic.

(D) could be slightly acidic, neutral or alkaline.

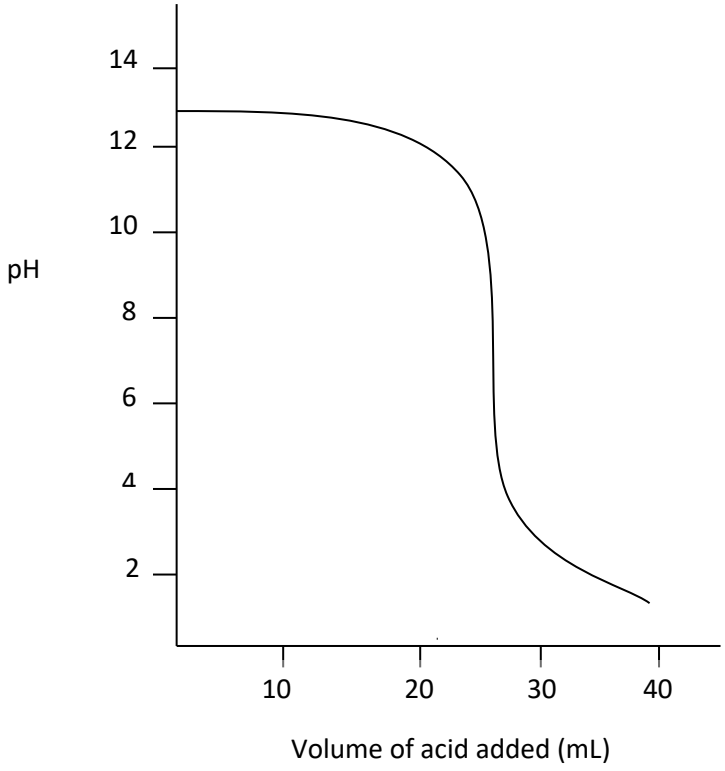
5. The conjugate acid of the dihydrogen phosphate ion is:

(A) $H_2PO_4^-$
(B) $HPO_4^-$
(C) $HPO_4^{2-}$
(D) $H_3PO_4$

6. Identify the product formed when ethanol is heated in the presence of concentrated sulfuric acid.

(A) Ethanoic acid
(B) Polyethylene
(C) Ethylene
(D) Ethane

7. What titration is represented by the curve shown in the diagram below?




(A) Strong base + weak acid
(B) Weak base + strong acid
(C) Strong base + strong acid
(D) Weak base + weak acid

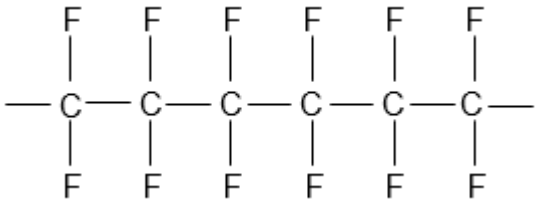
8. Which of the following describes a correct procedure to test for barium in 2 mL of a dilute solution?

(A) Add a few drops of dilute sulfuric acid.
(B) Add a few drops of dilute sodium hydroxide.
(C) Add a few drops of dilute hydrochloric acid, filter and heat the residue.
(D) Add a few drops of dilute sodium nitrate.

9. Which of the following pairs of chemicals could be used to make a buffer solution?

(A) $NH_3$ and $H_2O$
(B) HCl and NaCl
(C) $NH_3$ and $NH_4Cl$
(D) $CH_3COOH$ and HCl

10. Teflon is a strong, heat resistant polymer. Its structure is represented below.



What is the monomer used in the production of Teflon?

(A) Tetrafluoroethene
(B) Tetrafluoroethane
(C) Difluorohexene
(D) Difluoromethane

11. The forward reaction in the equilibrium shown below is endothermic.

$OCl^-(aq) + H2O(l) \rightleftharpoons HOCl(aq) + OH^-(aq)$

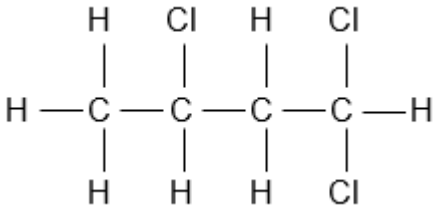
Which change increases the concentration of hypochlorous acid (HOCl)?

(A) Add water.
(B) Increase the pH.
(C) Lower the temperature.
(D) Add sodium hypochlorite, NaOCl(s).

12. What is the molecular formula of the monomer used in the production of polystyrene?

(A) $C_2H_4$
(B) $C_2H_3Cl$
(C) $C_6H_{12}O_6$
(D) $C_8H_8$

13. What is the correct name for the following compound?




(A) 1,3-trichlorobutane
(B) 1,1-dichloro-3-monochlorobutane
(C) 1,1,3-trichlorobutane
(D) 2,4,4-trichlorobutane

14. Which of the following identifies the main advantage of ethanol as a source of energy, compared with fossil fuels?

(A) Ethanol has higher energy content.
(B) Ethanol does not release carbon dioxide as a combustion product.
(C) Ethanol is a renewable source.
(D) Ethanol is cheaper.

15. Which one of the following aqueous solution will have a pH of less than7?

(A) Sodium Acetate
(B) Potassium chloride
(C) Ammonium chloride
(D) Sodium nitrate

16. The pH of a $5.0 \times 10^{-5}$ mol $L^{-1}$ solution of barium hydroxide is:

(A) 4.0
(B) 4.3
(C) 9.7

(D) 10.0

17. The heat of combustion of a straight-chained alkanol is 2500kJ/mol. Combustion of 0.74g of this alkanol causes a temperature change of 30.0$^{o}$C in 200g of water, with no heat loss to the surroundings.
Which of the following is a possible identity for this alkanol?

(A) 2-butanol
(B) 1- propanol
(C) Ethanol
(D) 1-pentanol

18. What is the pH of the resulting solution when 25.0 mL of 0.102 M HCl is mixed with 14.0 mL of 0.171M NaOH?

(A) 3.8
(B) 2.0
(C) 2.2
(D) 2.4

19. Citric acid (2-hydroxypropane-1,2,3-tricarboxylic acid), is the predominant acid in lemon juice. A student titrated 25.0 mL samples of lemon juice with 0.440 mol $L^{-1}$ NaOH. The mean titration volume was 29.50 mL. What was the concentration of citric acid in the lemon juice?

(A) 12.9 g $L^{-1}$
(B) 41.6 g $L^{-1}$
(C) 173 g $L^{-1}$
(D) 23.9 g $L^{-1}$

20. What is the maximum mass of ethanol that can be produced by the fermentation of 1.0 kg of glucose?

(A) 256g
(B) 489g
(C) 511g
(D) 1000g

**End of Part A**

## SECTION B

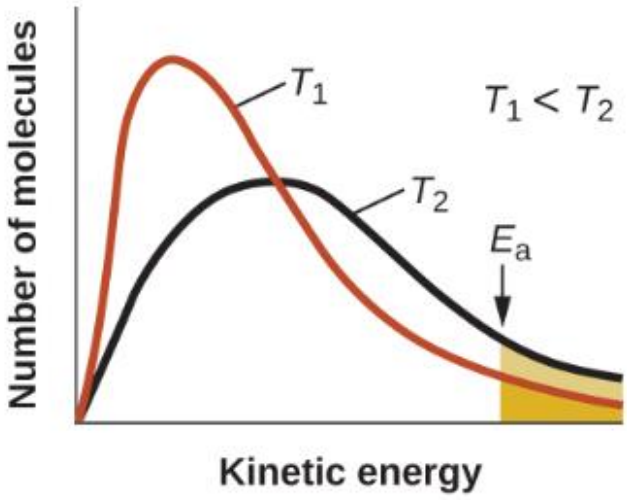
**Attempt Questions 21 to 37**

**Allow about 2 hour and 30 minutes for this part**

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

**Question 21 (2 marks)**

Analyse this graph to explain why increasing temperature increases reaction rate. **2**




……

……

……

……

**Question 22 (2 marks)** **2**

For the following reaction:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

the table below shows the values of the equilibrium constant at certain temperatures. Analyse the data to identify the relationship between temperature and the equilibrium constant, including whether it is an exothermic or endothermic reaction.

| Temperature K | Equilibrium constant K |
|---|---|
| 273 | $5.7 \times 10^{-4}$ |
| 298 | $4.7 \times 10^{-3}$ |
| 373 | 0.48 |
| 500 | 41.4 |

……

……

……

……

**Question 23 (4 marks)**

Wilhelm Ostwald developed a chemical process for the manufacture of nitric acid ($HNO_3$) in 1902.

This Ostwald process is a mainstay of the modern chemical industry, and it provides the main raw material for the most common type of fertiliser production.

A key step in the process produces nitrogen dioxide according to the following reaction:

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

A 2.0 litre reaction vessel initially contained 0.5 mole of NO(g) and 0.24 mole of $O_2(g)$. At equilibrium there was only 0.10 mole NO(g).

a) Write an equilibrium constant expression. **1**

b) Calculate the equilibrium constant **3**

**Question 24 (4 marks)**

The solubility of lead sulphate, in water at $25^0$C is 1.4 X $10^{-4}$ mol $L^{-1}$

a) Calculate its $K_{sp}$. **1**

……

……

b) Will a precipitate form if 50 mL of 2.0 X $10^{-4}$ mol $L^{-1}$ sodium sulphate solution is added to 200 mL of 2.0 X $10^{-4}$ mol $L^{-1}$ lead nitrate solution? **3**

……

……

……

……

……

……

**Question 25 (3 marks)**

The solubility product of lead (II) iodide at $35^0$C is 4.00 X $10^{-9}$ $mol^3$ $L^{-3}$.

Calculate the concentration of lead and iodide ions in a saturated solution of lead (II) iodide in water at $35^0$C. **3**

……

……

……

……

……

……

**Question 26 (4 marks)**

The reaction for photosynthesis is $6CO_2(g) + 6H_2O(l) \rightleftharpoons C_6H_{12}O_6(s) + 6O_2(g)$

The entropy of photosynthesis = -262 J $K^{-1}mol^{-1}$

a) Determine the enthalpy of photosynthesis based on the following table **2**

| Species | $C_6H_{12}O_{6(s)}$ | $O_{2(g)}$ | $CO_{2(g)}$ | $H_2O_{(l)}$ |
|---|---|---|---|---|
| Enthalpy of formation (kJ $mol^{-1}$) | -1273 | 0 | -393 | -285 |

b) Determine Gibbs free energy for photosynthesis at 298 K based on your answers to part a) and the entropy given in the question. **1**

……

……

c) From your answer in b) explain if photosynthesis is a spontaneous reaction or not? **1**

……

……

**Question 27 (9 marks)**

An analytical chemist wanted to test the reported concentration of a bottle of domestic cloudy ammonia. The bottle said that the concentration of ammonia in the bottle was 2%(w/v).

The chemist first diluted 25.00 mL of cloudy ammonia to 250.0 mL. She then pipetted 25.00 mL of the diluted solution into a clean, dry conical flask. She then took 50.00 mL of a 0.100 mol $L^{-1}$ standardised solution of hydrochloric acid and added it to the conical flask, where it reacted immediately.

The excess hydrochloric acid was then titrated against a standardised solution of 0.0500 mol $L^{-1}$ of sodium carbonate. The volumes of sodium carbonate required were:

| *Titre number* | *Volume (mL)* |
|---|---|
| 1 | 24.50 |
| 2 | 21.47 |
| 3 | 21.53 |
| 4 | 21.50 |

a) Write a balanced equation for the reaction between hydrochloric acid and sodium carbonate. **1**

……

……

b) Calculate the number of moles of excess hydrochloric acid from the first reaction. This amount of hydrochloric acid that reacted with sodium carbonate. **2**

……

……

……

……

c) Calculate the number of moles of hydrochloric acid that reacted with the ammonia in the first reaction. **2**

……

……

……

……

d) The reaction between ammonia and hydrochloric acid is:

$$NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$$ **1**

Determine the concentration of ammonia in the diluted cloudy ammonia solution.

……

……

e) Calculate the original concentration of cloudy ammonia. **1**

……

……

f) Was the concentration reported on the packaging accurate? Justify your answer. **2**

……

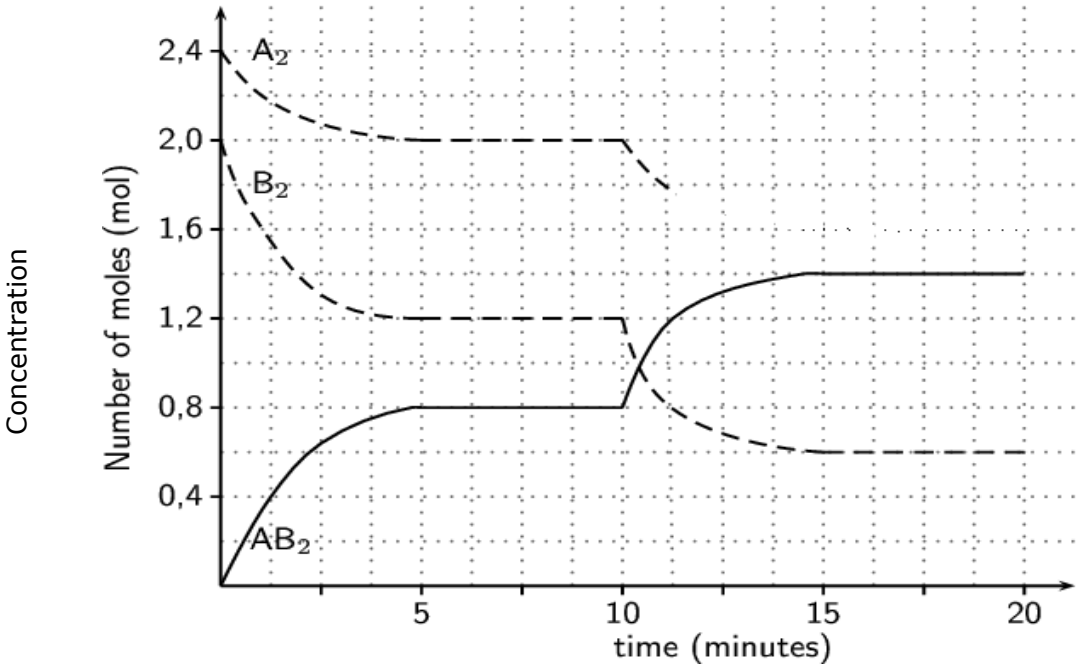
……

……

……

**Question 28 (6 marks)**

Information about the gaseous reaction between gases $A_2$, $B_2$ and $AB_2$ is represented below.




a) Write a balanced equation for the reaction. **1**

……

……

b) Identify the periods when the gases are in equilibrium and explain what is happening when the system is at equilibrium. **2**

……

……

……

……

c) Explain the reason for the changes in the graphs between 10 and 20 minutes. **2**

……

……

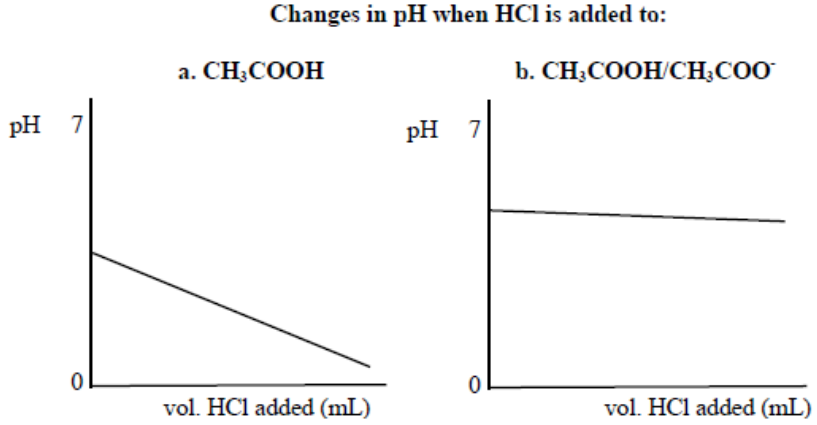
……

……

d) Complete the graph for gas $A_2$. **1**

**Question 29 (6 marks)**

a) A student used a data logger and pH probe to measure the pH of a solution of acetic acid, and an equimolar mixture of acetic acid with sodium acetate. Next, they added HCl to each solution, recording the pH as the HCl was added. Their results are shown in the graphs below.




Explain the different shapes of the two graphs, using a relevant chemical equation to illustrate your answer. **3**

……

……

……

……

……

……

b) Pure hydrogen chloride is a gas.

What volume of HCl(g) (measured at 25 °C and 100 kPa) would have to be dissolved in 2.00 L of water to produce a solution with a pH of 1.25? **3**

……

……

……

……

……

……

**Question 30 (3 marks)**

The table below shows the boiling points of some organic compounds.

| *Name* | *Molar mass (g mol$^{-1}$)* | *Boiling point (°C)* |
|---|---|---|
| Acetic acid | 60.1 | 117.9 |
| 1-propanol | 60.1 | 97.2 |
| Ethyl methanoate | 60.1 | 54.2 |

Explain the *difference* in boiling points between these three compounds. **3**

……

……

……

……

……

……

**Question 31 (2 marks)**

A student conducted the following experiment using a solution of acetic acid and a solution of hydrochloric acid. She measured the pH, and the results are summarised in the table below.

| | Acetic acid | Hydrochloric acid |
|---|---|---|
| Concentration of acid (mol $L^{-1}$) | 1.0 | 0.0040 |
| pH | 2.4 | 2.4 |

Explain how the same pH can occur for the two different acids shown in the table above. **2**

……

……

……

……

**Question 32 (7 marks)**

a) Name the products formed when butanoic acid and ethanol are refluxed with a concentrated sulfuric acid catalyst. **2**

……

……

……

……

b) Write a complete balanced equation for the reaction using structural formula. **2**

……

……

……

……

c) Explain the advantages of using reflux to prepare the ester. **2**

……

……

……

……

d) Identify a common use of an ester. **1**

……

……

**Question 33 (6 marks)**

A hydrocarbon contains 86% by weight of carbon and has a molecular weight of 70.

a) Determine the empirical and molecular formulae of the hydrocarbon. **3**

……

……

……

……

……

b) Draw and name 3 isomers of this molecular formula. **3**

……

……

……

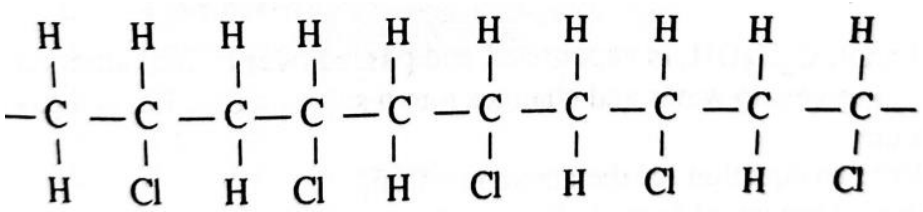
……

……

……

**Question 34 (3 marks)**

A section of a LARGE molecule is shown below:



a) What is the general name given to compounds of this type? **1**

……

……

b) Draw a structural formula, and name one of the smaller molecules which may have reacted to form this large molecule. **2**

**Question 35 (5 marks)**

Assess the suitability of ethanol as a fuel. **5**

……

……

……

……

……

……

……

……

……

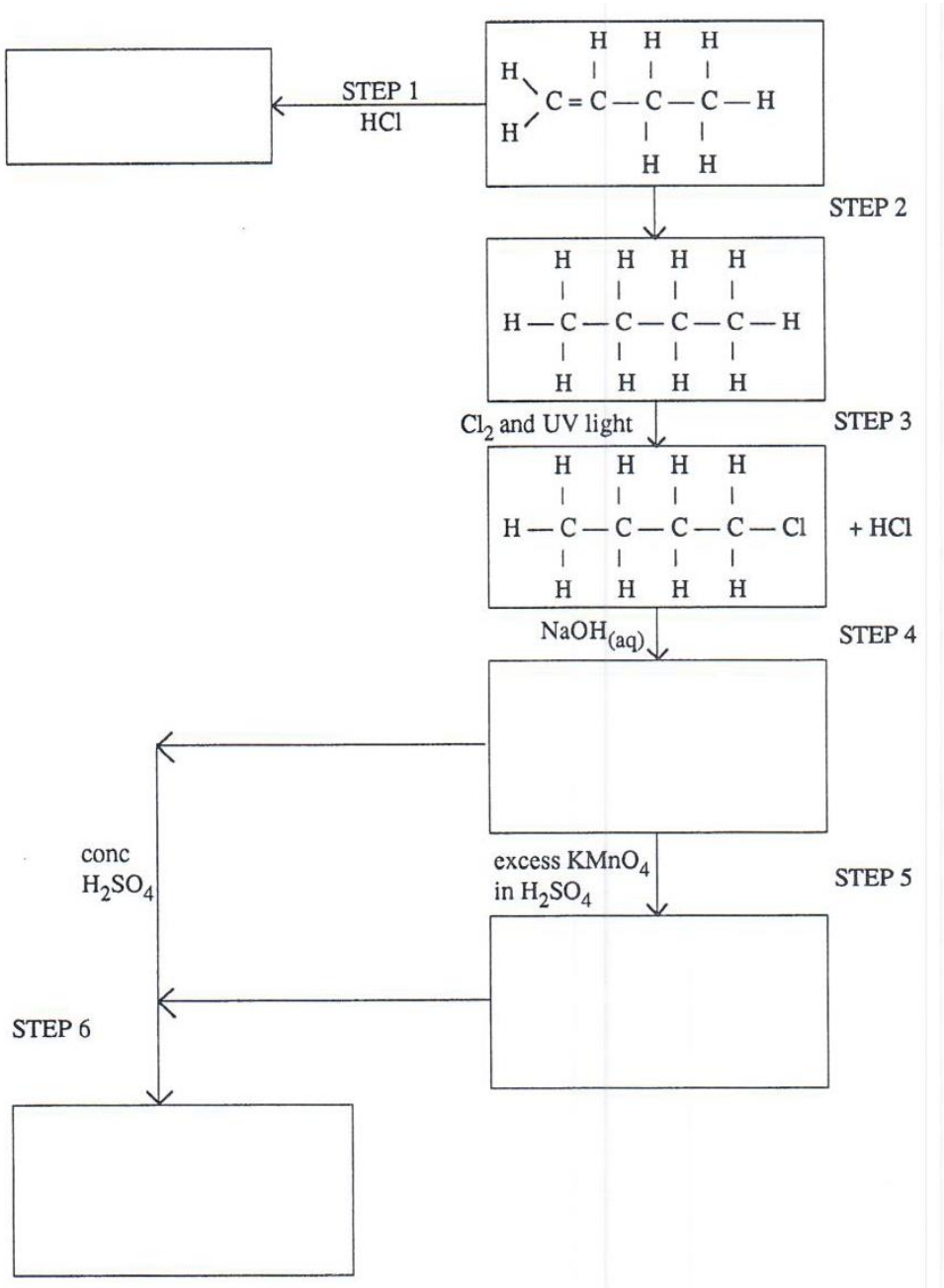
……

……

……

**Question 36 (7 marks)**

Use the flow diagram below to answer the following questions:




a) Name and draw the structural formula for the compound formed in Step 1. **2**

b) Name and draw the structural formula for the compound formed in Step 4 **2**

c) Give a chemical equation for the reaction involved in Step 5. **1**

d) Name and draw the compound formed in Step 6. **2**

**Question 37 (7 marks)**

Compound A, B and C each with formula $C_4H_8$ all react with bromine water to form compounds X, Y and Z. The formula of X, Y and Z are $C_4H_8Br_2$. **7**

A, B and C all react with HCl to form P,Q and R respectively, which all have the formulae $C_4H_9Cl$.

P, Q and R react with sodium hydroxide solution to form D, E and F respectively.

D and E undergo mild oxidation forming G and H respectively, formulae $C_4H_8O$. F does not oxidise.

Stronger oxidation of G forms one acid I.

Write structural formulae and name for A,B,C,X,Y,Z,P,Q,R,D,E,F,G,H and I.

**END OF PAPER**

**MARKING CRITERIA**

**SECTION A**

| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|
| A | D | C | C | D | C | C | A | C | A |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| D | D | C | C | C | D | C | A | D | C |

**SECTION B**

Q21

| **Marking Criteria** | **Marks** |
|---|---|
| Includes the relationship between kinetic energy and reaction rate including mentioning about activation energy and the graph | 2 |
| Includes the relationship between kinetic energy and activation energy/reaction rate or mentions something about the graph that make sense | 1 |

Suggested answer:

As the temperature **increases the kinetic energy increases which increases the number of molecules that have high enough kinetic energy to overcome the activation energy** and therefore react causing an increase in reaction rate. This can be shown on the larger shaded area.

Q22

| **Marking Criteria** | **Marks** |
|---|---|
| Includes the relationship between increasing temperature and higher K and implies it is a endothermic reaction | 2 |
| Includes the relationship between increasing temperature and higher K or implies it is an endothermic reaction | 1 |

Suggested answer:

*The table shows that the temperature at which K was calculated is continually increasing from 273 K to 500 K. The equilibrium constant K from 273 K to 500 K is increasing also e.g from $5.7x10^{-4}$ to 41.4. So, as temperature increases so does the value of K.*

*The value of K is calculated using the concentrations of the reactants and products by the equation*

$$K = \frac{[NO]^2}{[N_2O_4]}$$

*For the value of K to be increasing, the concentration of the NO e.g. [NO] must be also increasing and the concentration of the $N_2O_4$ e.g $[N_2O_4]$ must be decreasing. This will occur if the reaction proceeds to the right. If the temperature is increasing, by Le Chatelier's Principle, the reaction will move to try to counteract the change i.e remove the temperature. So, if the reaction moves to the right, then the reaction must be endothermic. The energy is added to the $N_2O_{4(g)}$ to produce the NO(g).*

Q23 (a)

| Marking Criteria | Marks |
|---|---|
| Correct equilibrium constant expression | 1 |

Suggested answer:

$K = [NO_2]^2 / [NO]^2 [O_2]$

Q23 (b)

| Marking Criteria | Marks |
|---|---|
| Uses ice to determine correct concentration of the equilibrium concentrations and then the calculation to determine the correct value | 3 |
| Makes one mistake any of the above e.g determine the wrong concentration of NO but has everything else correct | 2 |
| Has one correct piece of information for the concentration of **any one** of the reactants and products at equilibrium or has done the correct process in entering the values they have come up with into the equilibrium expression | 1 |

Suggested answer:

| | [NO] | $[O_2]$ | [NO2] |
|---|---|---|---|
| initial | 0.5/2 = 0.25 | 0.24/2 = 0.12 | 0 |
| Change in Concentration | 0.25-x = 0.05<br>Therefore = 0.2 | 0.1 | 0.2 |
| Equilibrium concentration | 0.1/2 = 0.05 | 0.02 | 0.2 |

$K = [0.2]^2 / [0.05]^2 \times 0.02$

$= 0.04 / 0.0025 \times 0.02$

$= 0.04 / .00005$

$= 800$

Q24 (a)

| Marking Criteria | Marks |
|---|---|
| Correct answer, no unit required | 1 |

Suggested answer:

$$PbSO_{4(s)} \leftrightarrow Pb^{2+} + SO_4^{2-}$$

$$K_{sp} = [Pb^{2+}][SO_4^{2-}] = (1.4 \times 10^{-4})^2 = 2.0 \times 10^{-8}\ mol^2.L^{-2}$$

Q24 (b)

| Marking Criteria | Marks |
|---|---|
| Correct concentration of both $Pb^{2+}$ and $SO_4^{2-}$ with correct substitution into $K_{sp}$ value. Correct judgement- no ppt | 3 |
| Correct concentration of both $Pb^{2+}$ and $SO_4^{2-}$ with correct substitution into $K_{sp}$ value. Incorrect judgement- no ppt | 2 |
| Incorrect concentration of both $Pb^{2+}$ and $SO_4^{2-}$ with correct substitution into $K_{sp}$ value and correct judgement | 1 |

Suggested answer:

$$Na_2SO_4 \leftrightarrow 2Na^+ + SO_4^{2-}$$

$$Pb(NO_3)_2 \leftrightarrow Pb^{2+} + 2NO_3^-$$

$$\therefore [Pb^{2+}] = 2 \times 10^{-4} \times \frac{200}{250} = 1.6 \times 10^{-4}\ mol.L^{-1}$$

$$[SO_4^{2-}] = 2 \times 10^{-4} \times \frac{50}{250} = 4.0 \times 10^{-5}\ mol.L^{-1}$$

$$\text{trial } K_{sp} = 1.6 \times 10^{-4} \times 4.0 \times 10^{-5} = 6.4 \times 10^{-9} < \text{real } K_{sp}$$

$\therefore$ no precipitate forms.

Q25

| Marking Criteria | Marks |
|---|---|
| Correct expression of $K_{sp}$ constant, correct x value and correct concertation of $Pb^{2+}$ and $I^-$ | 3 |
| Correct expression of $K_{sp}$ constant, incorrect x value and incorrect concertation of $Pb^{2+}$ and $I^-$ | 2 |
| Correct expression of $K_{sp}$ constant. | 1 |

Suggested answer:

$$PbI_2(s) \leftrightarrow Pb^{2+} + 2I^-(aq)$$

$$K_{sp} = [Pb^{2+}][I^-]^2$$

Let solubility $= x$

$\therefore [Pb^{2+}] = x$

$[I^-] = 2x$

$$4.0 \times 10^{-9} = x(2x)^3$$

$$x = 1 \times 10^{-3}$$

$\therefore$ solubility $PbI_2 = 1.0 \times 10^{-3}\ mol.L^{-1}$

$\therefore [Pb^{2+}] = 1.0 \times 10^{-3}\ mol.L^{-1}$

$[I^-] = 2.0 \times 10^{-3}\ mol.L^{-1}$

Q26 (a)

| Marking Criteria | Marks |
|---|---|
| Correct answer with correct units | 2 |
| Correct answer with incorrect units or correct setting out but calculation is incorrect | 1 |

Suggested answer:

$$\Delta H^0 = 6\Delta H_f^0\left(O_2(g)\right) + \Delta H_f^0\left(C_6H_{12}O_6(s)\right) - 6\Delta H_f^0\left(CO_2(g)\right) - 6\Delta H_f^0\left(H_2O(l)\right)$$
$$= 6(0) + (-1274.45kJ) - 6(-393.51kJ) - 6(-285.84kJ) = +2801.65kJ$$
$$\Delta S^0 = 6S^0\left(O_2(g)\right) + S^0\left(C_6H_{12}O_6(s)\right) - 6S^0\left(CO_2\right) - 6S^0\left(H_2O(l)\right)$$
$$= 6(205.03J/K) + 212.13J/K - 6(213.64) - 6(69.94J/K) = -259J/K$$

Q26 (b)

| Marking Criteria | Marks |
|---|---|
| Correct answer with correct units | 1 |

Suggested answer:

Gibbs free energy formula states $\Delta G = \Delta H - T\Delta S$

$\Delta G = \Delta H - T\Delta S$
$= 2795 – (298 \times -262/1000)$
$= 2795 + 78$

$= 2873$ kJ mol$^{-1}$

Q26 (c)

| Marking Criteria | Marks |
|---|---|
| Correct answer | 1 |

Suggested answer:

If ΔG greater than 0 then it must be a non-spontaneous reaction

Q27 (a)

| Marking Criteria | Marks |
|---|---|
| Writes a balanced equation with states | 1 |

Suggested answer:

Na2CO3(aq) + 2HCl(aq) → 2NaCl(aq) + CO2(g) + H2O(l)

Q27 (b)

| Marking Criteria | Marks |
|---|---|
| Calculates the number of moles sodium carbonate and then the number of moles of HCl | 2 |
| Calculates moles of sodium carbonate only | 1 |

Suggested answer:

n = 0.05 * 0.0215
= 0.001075 mol

n(HCl) = 2*n(Na2CO3)
= 0.001075 * 2
= 0.00215 mol excess

Q27(c)

| Marking Criteria | Marks |
|---|---|
| Calculates original moles of HCl then used moles of HCl | 2 |
| One of the above only | 1 |

Suggested answer:

0.05 * 0.01 = 0.025 mol in original HCl solution
0.00215 mol used by Na2CO3

Therefore 0.025 – 0.00215 mol consumed by NH3

= 0.00285

Q27 (d)

| Marking Criteria | Marks |
|---|---|
| Calculates concentration of ammonia in the dilute solution | 1 |
| | |

Suggested answer:

N(NH3) = N(HCl) = 0.00285 mol
C(NH3) = 0.00285/0.025 = 0.114 mol/L

Q27(e)

| Marking Criteria | Marks |
|---|---|
| Calculates the original concentration of the ammonia | 1 |
| | |

Suggested answer:

0.114 * 0.250 = C2 * 0.025

C2 = 1.14 mol/L

Q27 (f)

| Marking Criteria | Marks |
|---|---|
| Converts the concentration and correctly assesses the accuracy | 2 |
| Incorrectly calculates concentration but makes correct assessment of accuracy on that basis | 1 |

Suggested answer:

2%(w/v) = 2g/100ml = 20 g/L

20/(14.01+3*1.008) = 1.17 mol/L ~ 1.14 mol/L

Therefore the packaging was fairly accurate

Q28 (a)

| Marking Criteria | Marks |
|---|---|
| Writes a balanced equation | 1 |
| | |

Suggested answer:

A2 + 2B2 <-> 2AB2

Q28 (b)

| Marking Criteria | Marks |
|---|---|
| Identifies a correct time period and explains what is happening at equilibrium | 2 |
| Identifies correct time period only | 1 |

Suggested answer:

The gases are at equilibrium between 5 and 10 minutes, and 15 minutes and beyond. At equilibrium, the forward reaction rate is equal to the back reaction rate, so the overall concentration of no gas is changing.

Q28(c)

| Marking Criteria | Marks |
|---|---|
| Identifies what is happening as per the graphs at 10 minutes AND explains the reason for the changes in the graphs between 10 and 20 minutes | 2 |
| Identifies what is happening as per at 10 minutes OR explains the reason for the changes in the graphs between 10 and 20 minutes | 1 |

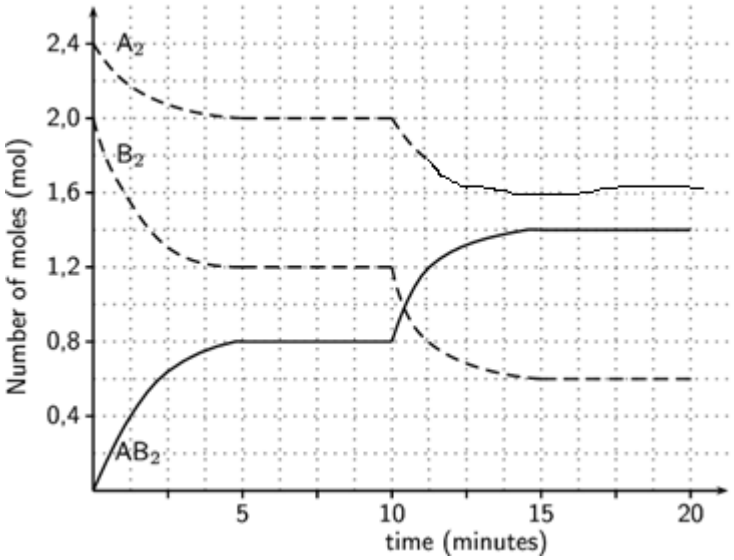
Suggested answer:

At the 10-minute mark, the equilibrium is disturbed by a change in temperature, which favours the forward reaction. As a result, the concentrations of $A_2$ and $B_2$ fall. A new equilibrium is reached just before the 15-minute mark, which has fewer moles of $A_2$ and $B_2$ than previously but more moles of $AB_2$.

Q28 (d)

| Marking Criteria | Marks |
|---|---|
| Completes the graph correctly for gas $A_2$ | 1 |
| | |

Suggested answer:




Q29 (a)

| Marking Criteria | Marks |
|---|---|
| Explains that solution (b) is a buffer and outlines why it resists changes in pH including an appropriate chemical equation. | **3** |
| Identifies that solution (b) is a buffer and identifies that it resists changes in pH or includes an appropriate chemical equation. | **2** |
| Identifies that solution (b) resists changes in pH or identifies that solution (b) is a buffer. | **1** |

Suggested answer:

Solution $CH_3COO^-$/ $CH_3COOH$ acts as a buffer and is able to resist pH change when a little amount of HCl is added.

$CH_3COOH \longleftrightarrow CH_3COO^- + H^+$

When some $H^+$ is added, it will combine with $CH_3COO^-$ and equilibrium will shift to the left hand side to use up all the $H^+$ hence pH is maintained.

When some $H^+$ is added to $CH_3COOH$ solution, the concentration of $H^+$ will increase hence pH decreases sharply.

Q29 (b)

| Marking Criteria | Marks |
|---|---|
| Calculates the volume of HCl(g) required to 2 significant figures and includes the units. | **3** |
| Response contains one error. | **2** |
| Response contains one correct step. | **1** |

Suggested answer:

$[H^+] = 10^{1.25} = 0.056234$ mol L-

mol of HCl in 2L = 2X 0.056234 = 0.112468

Vol of HCl = 0.112468 X 24.79 = 2.8L

Q30

| Marking Criteria | Marks |
|---|---|
| Relates the boiling point of a substance to the strength of its intermolecular forces AND<br>Identifies that polarity and hydrogen bonding are significant forces between molecules AND<br>Identify that the acid can form more H-bond compared to alcohol | 3 |
| Relates the boiling point of a substance to the strength of its intermolecular forces OR<br>Identifies that polarity and hydrogen bonding are significant forces between molecules OR<br>Identify that the acid can form more H-bond compared to alcohol | 1-2 |

Suggested answer:
The boiling point of a substance is determined by the strength of its intermolecular forces. The stronger the forces, the higher the boiling point. Ethyl methanoate has lower polarity than acetic acid and 1-propanol and so has weaker dipole-dipole attractions between molecules. Acetic acid and 1-propanol also contain -OH groups and so can also establish hydrogen bonding between molecules, giving them higher boiling points. The more extensive hydrogen bonding in acetic acid gives it a higher boiling point than 1-propanol.

Q31

| Marking Criteria | Marks |
|---|---|
| Identifies the strengths of the two acids AND<br>Compares the degree of ionisation of the two acids to the $H^+$ concentration and hence the same pH reading. | 2 |
| Identifies the strengths of the two acids OR<br>Explains one aspect of concentrations and pH readings. | 1 |

Example:
Despite having the same initial pH of 2.4, which indicates the $[H^+]$ in both were equal, the actual concentrations of the acids were very different.
This reflects the different strengths of the two acids. Hydrochloric acid is strong and totally ionises whereas acetic acid is weak and only ionises partially. Therefore, despite the acetic acid having a much higher acid concentration of 1.0 mol $L^{-1}$, the $[H^+]$ in acetic acid must be only 0.0040 mol $L^{-1}$.

Q32 (a)

| Marking Criteria | Marks |
|---|---|
| Ethyl butanoate **and** Water | 2 |
| Ethyl butanoate **Or** Water | 1 |

Suggested answer:

Ethyl butanoate and water

Q32 (b)

| Marking Criteria | Marks |
|---|---|
| Correct structural formula for all species | 2 |
| One incorrect structural formula | 1 |

Suggested answer:

Q32 (c)

| Marking Criteria | Marks |
|---|---|
| Explain that process is slow at room temp and therefore heat is needed to increase rate and reflux is used to prevent loss of material | 2 |
| State increase rate or mention prevent loss of volatile material | 1 |

Suggested answer:

Esterification is a slow process at room temperature. To increase rate of reaction, heat is needed and reflux is used to prevent loss of volatile materials.

Q32 (d)

| Marking Criteria | Marks |
|---|---|
| Artificial flavours OR perfumes | 1 |

Suggested answer:

Artificial flavours or perfumes.

Q33 (a)

| Marking Criteria | Marks |
|---|---|
| Correct no of mols for C and H. Correct whole ratio with correct empirical formula. Correct molecular formula. | 3 |
| Correct no of mols for C and H. Correct whole ratio with correct empirical formula | 2 |
| Correct no of mols for C and H. | 1 |

Suggested answer:

| | C | H |
|---|---|---|
| Mass | 86 | 14 |
| mol | 7.1606 | 13.889 |
| Ratio | 1 | 1.94 |

Empirical formula: $CH_2$

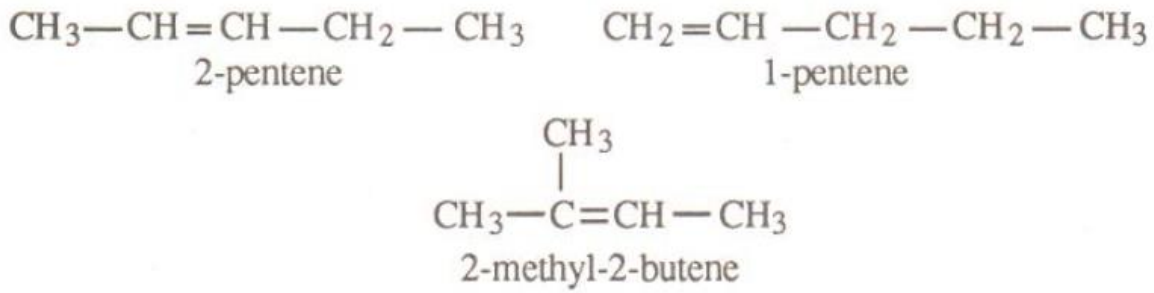
n = 70/(12.01 + 2X1.008) = 4.99

Molecular formula = $C_5H_{10}$

Q33 (b)

| Marking Criteria | Marks |
|---|---|
| All 3 correct isomers | 3 |
| 2 correct isomers | 2 |
| 1 correct isomer | 1 |

Suggested answer:




Q34 (a)

| Marking Criteria | Marks |
|---|---|
| correct name | 1 |

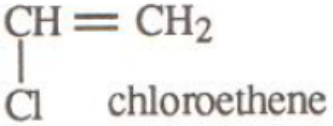
Suggested answer:

Polymer

Q34 (b)

| Marking Criteria | Marks |
|---|---|
| Correct structure and name | 2 |
| Correct structure or name | 1 |

Suggested answer:



Q35

| Marking Criteria | Marks |
|---|---|
| Evaluation includes relating ethanol as a biofuel to sustainability. Describes two advantages and two disadvantages of using ethanol as a fuel. Include all relevant equations (photosynthesis, fermentation, combustion) Judgment must be criteria based. Logical and coherent response. | 5-4 |
| Describes two advantages of ethanol as a fuel OR describes two disadvantages of ethanol as a fuel OR describes one advantage and one disadvantage of ethanol as a fuel. Include some equations and a judgment given but not criteria based. | 3 |
| Describes one advantage and one disadvantage of ethanol as a fuel and include some equations with a judgment. | 2 |
| Describes one advantage<br>OR<br>Describes one disadvantage<br>OR<br>Give two relevant equations | 1 |

Suggested answer:

Ethanol is a biofuel grown from crops such as sugar can and corn. It is blended with petrol and is used to run cars.

An advantage of blending fuels is that our non-renewable oil reserves will last longer and we will be less dependant on foreign countries for our energy. Another advantage of using ethanol is that combustion releases less $CO_2$ than petrol and growing the crop absorbs $CO_2$, hence ethanol is claimed to be carbon neutral. $CO_2$ emissions are blamed for causing anthropogenic climate change.

The crop grows by photosynthesis which absorbs $CO_2$ from the atmosphere.

$6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$

The sugar then needs to be fermented to obtain ethanol

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + \text{heat}$

Combustion of ethanol releases energy to power the vehicle.

$2C_2H_5OH + 6O_2 \rightarrow 4CO_2 + 6H_2O + \text{heat}$

Therefore the amount of $CO_2$ extracted by the crop from the atmosphere is equal to what is emitted.

However, the claim of being carbon neutral does not take into account harvesting, processing and transport requirements. Also, huge amounts of land that once produced food for human consumption are now growing crops for biofuels. This has led to a sharp increase in world food prices, particularly in the developing world. This is leading to malnutrition and starvation.

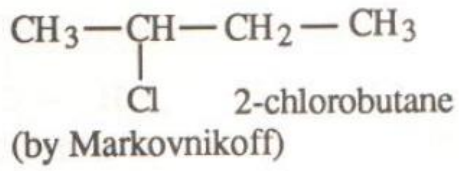
Combustion of ethanol also releases less energy than a similar mass of petrol resulting in less distance that can be travelled between refills. Ethanol blended fuels can only be used in cars designed for them as they can corrode and pit the fuel systems in non-compatible cars.

Overall the use of ethanol as a fuel is problematic. With the ever increasing world population there is a need for increased food production. This requires agricultural land producing food instead of biofuels as these already have a cheap and reliable source.

Q36 (a)

| Marking Criteria | Marks |
|---|---|
| Correct structure and name | 2 |
| Correct structure or name | 1 |

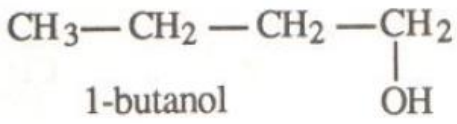
Suggested answer:




Q36 (b)

| Marking Criteria | Marks |
|---|---|
| Correct structure and name | 2 |
| Correct structure or name | 1 |

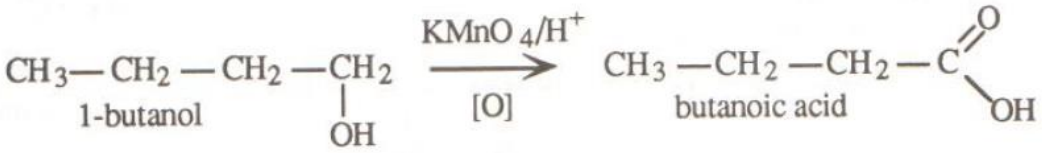
Suggested answer:




Q36 (c)

| Marking Criteria | Marks |
|---|---|
| Correct chemical equation | 1 |

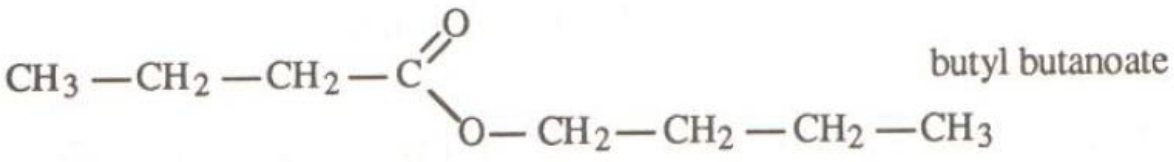
Suggested answer:




Q36 (d)

| Marking Criteria | Marks |
|---|---|
| Correct structure and name | 2 |
| Correct structure or name | 1 |

Suggested answer:



Q37

| Marking Criteria | Marks |
|---|---|
| Correct structure and name for A,B,C,X,Y,Z,P,O,R,D,E,F,G,H and I | 7 |
| Every incorrect structure or name minus 1 | |

Suggested answer: