
Student Number

NORTH SYDNEY GIRLS HIGH SCHOOL

2022

Higher School Certificate Trial Examination

Chemistry

General Instructions

- Reading Time – 5 minutes
- Working Time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used.
- A formulae sheet, data sheet and Periodic Table are provided
- Write your student number at the top of the booklet and on the multiple choice answer sheet.

Total Marks – 100

Weighting – 30%

Section I **20 Marks**

Attempt Questions 1 - 20

Allow about 35 minutes for this section

Section II **80 Marks**

Attempt Questions 21 - 34

Allow about 2 hours and 25 minutes for this section

Section I

20 marks

Attempt Questions 1–20 Allow about 35 minutes for this section

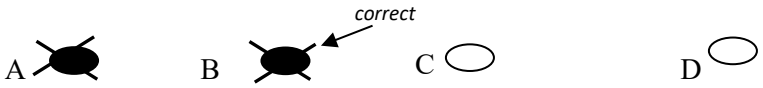
Use the multiple-choice answer sheet provided for Questions 1-20. If you must use blank paper instead, clearly indicate an answer of EITHER A, B, C or D for each question from 1-20.

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

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

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:



1 Which of the following is a valid way of converting an alkene into an alkane?

A. React with hydrogen gas

B. React with water

C. React with concentrated sulfuric acid

D. Shine with ultra violet light

2 Which of the following statements is NOT an important feature of a primary standard solution?

A. Stable

B. Absorbs moisture from air

C. Known chemical formula

D. High molecular mass

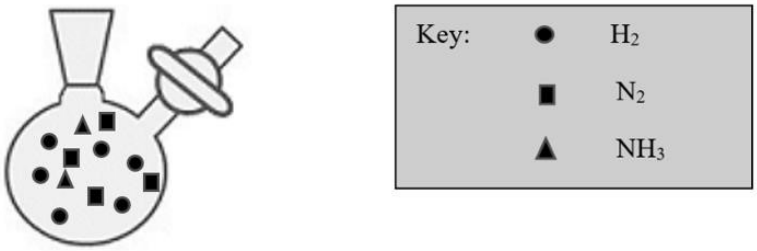
3 A student attempts to conduct a titration to determine the concentration of NaOH against a primary standard. They plan to set up the burette with the NaOH and the conical flask with the primary standard. Based on this plan, which of the following matches the correct rinsing solution to the correct equipment?

	Burette	**Conical flask**	**Pipette**
A.	NaOH	Distilled water	Primary standard
B.	Distilled water	Primary standard	NaOH
C.	NaOH	NaOH	Distilled water
D.	NaOH	Primary standard	Primary standard

4 The reaction between hydrogen and nitrogen gas to form ammonia is reversible and will come to equilibrium under suitable conditions.

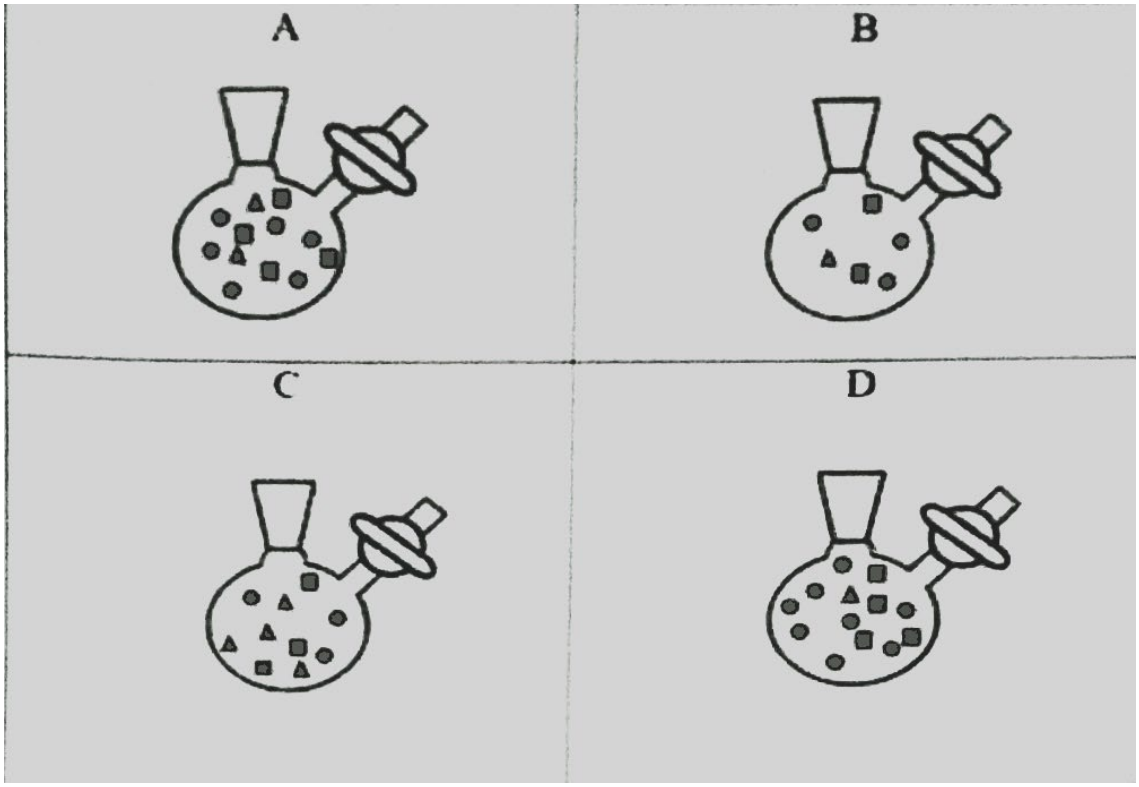
$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)} \quad \Delta H = -92 \text{ kJ mol}^{-1}$$

The diagram below represents a mixture of the relevant gases at equilibrium at 25°C.

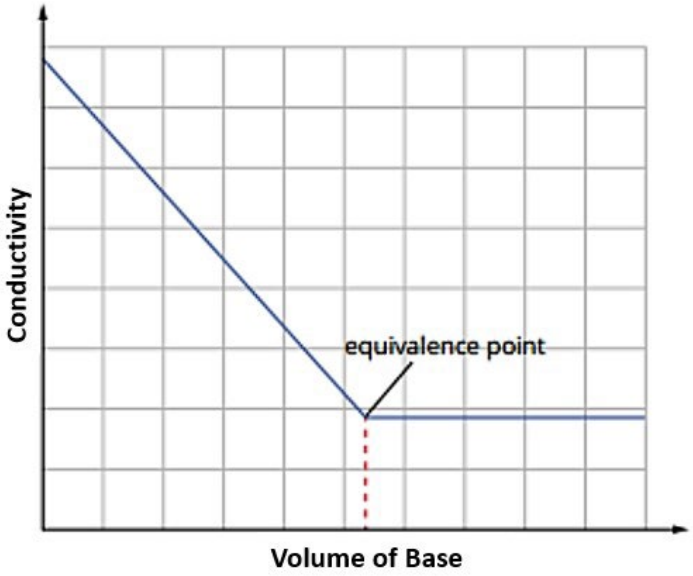


The flask was cooled and the system re-established equilibrium at a temperature of 4°C.

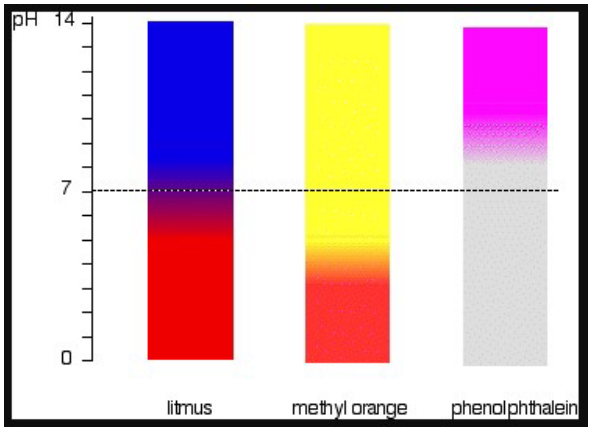
Which diagram best represents the composition of the flask at equilibrium?



5 A conductivity titration experiment was conducted on a reaction between an acid and base. The graph below was generated from the results collected.



The diagram below shows the pH range of colour change for some indicators.



Which of the following would be an appropriate choice of indicator for a titration involving the same acid and base?

A. Litmus

B. Methyl orange

C. Phenolphthalein

D. Any indicator

6 A student carried out an investigation into the behaviour of hydrated copper sulfate when it was heated in an open test tube. The following extract is from the rough notes written by the student:

1. ***A sample of hydrated copper sulfate was put into a test tube. The copper sulfate was a bright blue solid.***
2. ***The test tube was heated carefully using a Bunsen Burner flame. When heated, the copper sulfate gave off a vapour.***
3. ***The solid was allowed to cool. When cooled, the solid was white.***
4. ***Water was added to the solid. The solid became bright blue and the test tube became warm.***

Based on the information given, what should the student conclude?

A. The procedure shows a reversible reaction.

B. The procedure shows a static equilibrium.

C. Copper sulfate combusts when heated.

D. Copper sulfate is an ionic substance.

7 Which of the following equations shows the first species in the reaction acting as a Bronsted-Lowry base but not an Arrhenius base?

A. $HCl_{(aq)} + H_2O_{(l)} \rightarrow Cl^-_{(aq)} + H_3O^+_{(aq)}$

B. $OH^-_{(aq)} + H_3O^+_{(aq)} \rightarrow 2H_2O_{(l)}$

C. $CH_2C_6H_5^-{}_{(aq)} + NH_{3(aq)} \rightarrow CH_3C_6H_{5(aq)} + NH_2^-{}_{(aq)}$

D. $HCl_{(aq)} + NH_{3(aq)} \rightarrow NH_4^+{}_{(aq)} + Cl^-_{(aq)}$

8 Which combination of reagents would have the highest expected temperature rise after mixing?

A. 200 mL 0.1 mol L^{-1} HNO_3
300 mL 0.1 mol L^{-1} NaOH

B. 400 mL 0.1 mol L^{-1} HNO_3
600 mL 0.1 mol L^{-1} NaOH

C. 150 mL 0.2 mol L^{-1} HNO_3 150
mL 0.2 mol L^{-1} NaOH

D. 250 mL 0.1 mol L^{-1} CH_3COOH 250
mL 0.1 mol L^{-1} NaOH

9 Calcium nitrate thermally decomposes to form calcium oxide, nitrogen dioxide and oxygen. The table below lists the thermochemical data for this reaction.

	$Ca(NO_3)_{2(s)}$	$CaO_{(s)}$	$NO_{2(g)}$	$O_{2(g)}$
$\Delta_f H^o$ (kJ mol^{-1})	-938	-635	33	0
$\Delta_f S_o$ (J mol^{-1} K^{-1})	193	38	240	205

At what temperature will the reaction change from being non-spontaneous to spontaneous?

A. 863 ºC

B. 863 K

C. 8.63 ºC

D. 8.63 K

10 What is the temperature of the resultant solution after 25.0 mL of 1.0 mol L^{-1} sulfuric acid was mixed with 40 mL of 1.5 mol L^{-1} lithium hydroxide? Assume that $\Delta H_{neutralisation} = -55.9$ kJ mol^{-1} and the initial temperature of each reactant was 25ºC.

A. 30ºC

B. 35ºC

C. 37ºC

D. 42ºC

11 Ascorbic acid ($H_2C_6H_6O_6$) has a K_a of 7.9 x 10^{-5}. Carbonic acid (H_2CO_3) has a K_a of 4.5 x 10^{-7}.

Which of the following 0.1 mol L^{-1} solutions would have the highest pH?

A. $H_2C_6H_6O_6$

B. H_2CO_3

C. $NaHC_6H_6O_6$

D. $NaHCO_3$

12 Which of the following compounds would have the highest pH?

A. propan-1-amine

B. propanamide

C. propanoic acid

D. propan-1-ol

13 Which of the following is the correct order of the compounds from least soluble to most soluble in water?

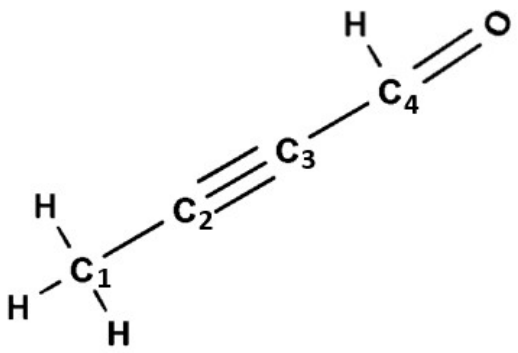
A. chloroethane, prop-1-ene, ethanol, propan-1-ol

B. butane, chloropropane, butan-1-ol, propan-1-ol

C. but-2-ene, butanoic acid, butane, butan-2-ol D. butanoic acid, butan-1-ol, but-2-ene, butane

D. butanoic acid, butan-1-ol, but-2-ene, butane

14 The structure of a compound is shown below. Its carbon atoms are labelled 1 to 4.



Which of the following correctly describes the shape around each carbon atom?

	Carbon 1	**Carbon 2**	**Carbon 3**	**Carbon 4**
A.	Linear	Linear	Linear	Tetrahedral
B.	Tetrahedral	Linear	Linear	Tetrahedral
C.	Trigonal Planar	Linear	Linear	Tetrahedral
D.	Tetrahedral	Linear	Linear	Trigonal Planar

15 A sample of vinegar has a density of 1.01 g mL^{-1} and contains 3.00% by mass of ethanoic (acetic) acid. What volume of 0.500 mol L^{-1} potassium hydroxide is required to neutralise 25.0 mL of the vinegar?

A. 1.00×10^{-2} L

B. 1.26×10^{-2} L

C. 2.52×10^{-2} L

D. 3.03×10^{-2} L

16 Which of the following lists show the solutions in order from lowest to highest electrical conductivity?

A. 0.05 mol L^{-1} acetic acid; 0.05 mol L^{-1} hydrochloric acid; 0.1 mol L^{-1} sodium hydroxide; 0.1 mol L^{-1} calcium hydroxide

B. 0.1 mol L^{-1} calcium hydroxide; 0.1 mol L^{-1} sodium hydroxide; 0.05 mol L^{-1} hydrochloric acid; 0.05 mol L^{-1} acetic acid

C. 0.1 mol L^{-1} sodium hydroxide; 0.1 mol L^{-1} calcium hydroxide; 0.05 mol L^{-1} hydrochloric acid; 0.05 mol L^{-1} acetic acid

D. 0.05 mol L^{-1} acetic acid; 0.05 mol L^{-1} hydrochloric acid; 0.1 mol L^{-1} calcium hydroxide; 0.1 mol L^{-1} sodium hydroxide

17 A solution of crystalline diprotic oxalic acid ($H_2C_2O_4.2H_2O$) is prepared by dissolving 12.6 g of the acid in 4.00 L of water. A 20.0 mL volume of this solution is required to completely neutralise 36.0 mL of a potassium hydroxide solution. What is the concentration of the potassium hydroxide solution?

A. 0.0194 mol L^{-1}

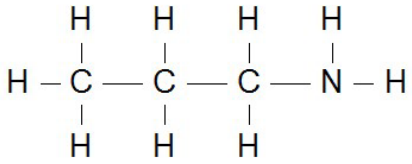
B. 0.0139 mol L^{-1}

C. 0.0389 mol L^{-1}

D. 0.0278 mol L^{-1}

18 Under appropriate conditions glucose will react with yeast to produce compound X and carbon dioxide gas. Compound X can then be oxidised with heat to produce compound Y.

Compound Y is then reacted with the compound shown below.



Which of the following is the preferred IUPAC name of the final product formed?

A. *N*-ethylpropanamide

B. *N*-ethylpropanamine

C. *N*-propylethanamide

D. *N*-propylethanamine

19 A 0.30 g sample of propan-2-ol was burned in a spirit burner placed under an open flask which contained 100 g of water initially at 25ºC. When heating was finished it was determined that 45% of the heat produced was lost to the environment. The theoretical enthalpy of combustion of propan-2-ol is -2644 kJ mol^{-1}.

What was the final temperature of the water?

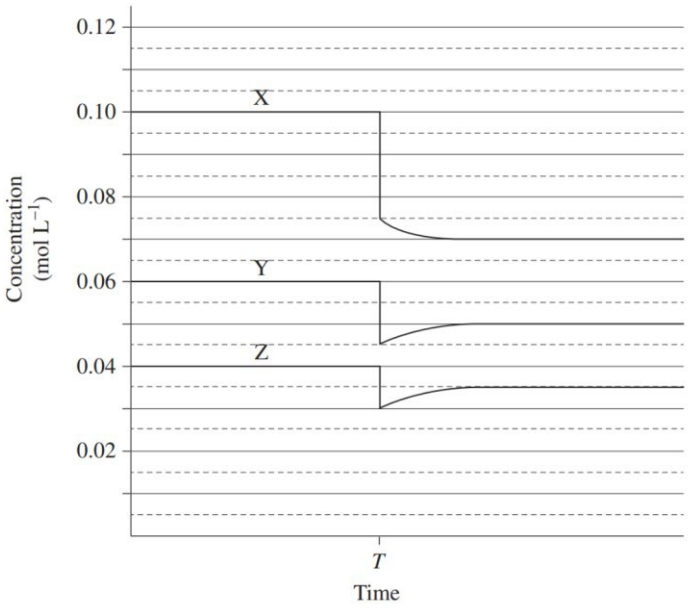
A. 32ºC

B. 39ºC

C. 42ºC

D. 57ºC

20 Three gases X, Y and Z were mixed in a closed container and allowed to reach equilibrium. A change was imposed at time T and the equilibrium was re-established. The concentration of each gas is plotted against time.



Which of the values below is closest to the equilibrium constant value K for the reaction if X is considered to be the reactant?

A. 2.4 x 10^{-2}

B. 0.24

C. 42

D. 255

Section II

80 marks

Show all relevant working in questions involving calculations.

Question 21 (4 marks)

a) 2,2-diethylbutane is the incorrect name for a compound. Explain why this name is incorrect and give the correct name. **2**

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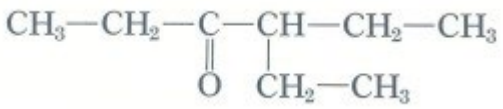
b) Name the following two compounds: **2**



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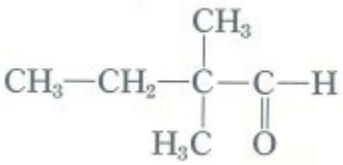

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Question 22 (2 marks)

Identify the conjugate acid of the following species.

a) HPO_4^- …… **1**

b) O^{2--} …… **1**

Question 23 (4 marks)

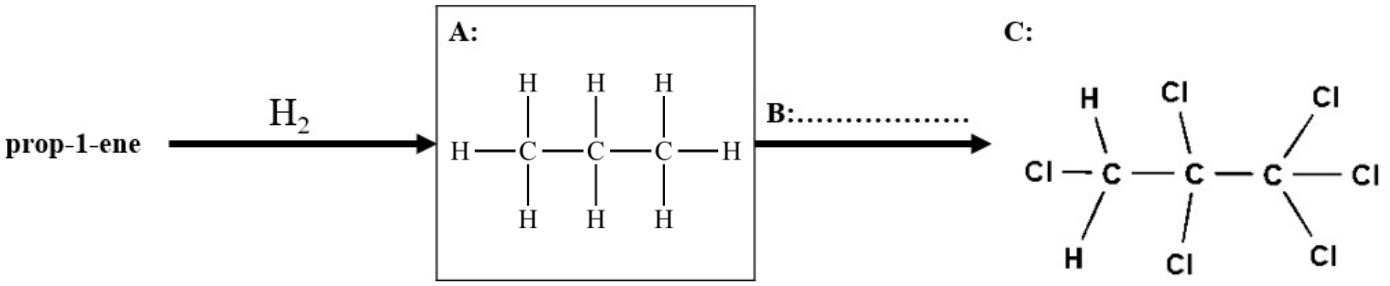
Complete the table below to outline ONE advantage and ONE disadvantage for each fuel category. **4**

Type of fuel	Advantages	Disadvantages
Fossil Fuel	…… …… …… …… ……	…… …… …… …… ……
Biofuel	…… …… …… …… ……	…… …… …… …… ……

Question 24 (4 marks)

Complete the flow chart below by: **4**

- identifying the structural formula and name of compound A
- identifying reagent/conditions B
- identifying name of compound C



IUPAC name: …… **IUPAC name:** ……

Question 25 (7 marks)

A student completely neutralised a 50 mL aliquot of 0.1 mol L^{-1} NaOH using a 50 mL aliquot of 0.1 mol L^{-1} HCl. They were then surprised to discover that 50 mL of 0.1 mol L^{-1} propanoic acid also neutralised the same volume and concentration of NaOH solution.

a) Explain why the same volume of both acids was required to neutralise the NaOH solution, even though one was strong and one was weak. **3**

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b) The student then compared the pH of the NaOH solution neutralised by the HCl (Reaction X) with the pH of the NaOH solution neutralised by the propanoic acid (Reaction Y) and found that they were different. Using relevant chemical equation(s), account for the difference in pH of the two solutions and identify which had the higher pH. **4**

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Question 26 (4 marks)

Hydrogen iodide gas decomposes to form hydrogen gas and iodine gas as indicated in the reaction below. Hydrogen iodide and hydrogen are colourless gases and iodine is a purple gas.

$$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$$

The equilibrium constant (K_{eq}) for this reaction is 2.18×10^{-2} at 490°C.

a) 3.085 g of hydrogen iodide was placed in a 200 mL flask and the temperature of the system was raised to 490ºC. The concentration of iodine gas after a minute was found to be 0.0274 mol L^{-1}. Using calculations, determine whether this system is at equilibrium. **3**

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b) What observation could be made to <u>qualitatively</u> determine if the system had reached equilibrium? **1**

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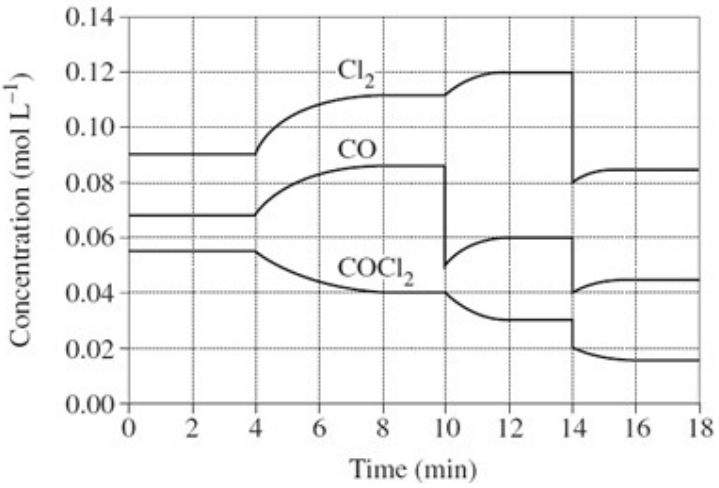
Question 27 (7 marks)

Phosgene ($COCl_2$) is a poisonous gas that dissociates at high temperatures into two other poisonous gases, carbon monoxide and chlorine.

$$COCl_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)} \qquad \Delta H = +108 \text{ kJ mol}^{-1}$$

The following shows the concentration of the species of this reaction as three changes were made to the system.



a) Identify the change imposed on the system at 4 min. **1**

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b) Using collision theory, explain the change in concentrations of the species between 4 min and 8 min. **3**

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Question 27 continued on the next page

c) Phosgene at 105.0 kPa is allowed to come to equilibrium in a fixed volume at 527 K. The equilibrium pressure of carbon monoxide at this temperature is measured to be 39.0 kPa. Using concentrations of the species in mol L^{-1}, calculate the equilibrium constant K for this system. **3**

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End of Question 27

Question 28 (5 marks)

Using calculations, compare the molar solubility of silver phosphate in water with its solubility in 0.100 mol L^{-1} silver nitrate (both at 25°C). **5**

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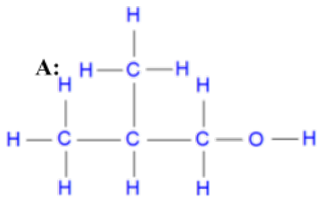
Question 29 (9 marks)

The following represents a 2-step conversion reaction:

a) Complete the flow chart above by naming compounds A, C and E and reagents B and D and providing the structural formula for compound C in the spaces provided. **5**

A: 

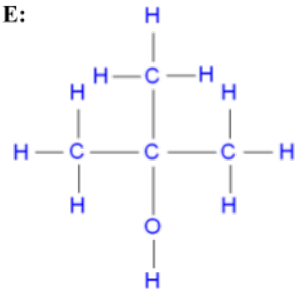
IUPAC name: .....

B: .....

C:

IUPAC name: .....

B: .....

E: 

IUPAC name: .....

b) Compounds A and E in the above reaction can be considered isomers of one another. What type of isomers are they? **1**

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c) Name a chemical reaction that could be used to distinguish between compounds A and E. **1**

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Question 29 continued on the next page

d) Identify one hazard when carrying out first hand investigations with alcohols and suggest one precaution that can be taken. **2**

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End of Question 29

Question 30 (8 marks)

Ammonia ionises in water to a small extent. At 298 K, the equilibrium concentrations of the relevant species are shown in the table below.

Species	Concentration (mol L^{-1})
NH_3	0.980
NH_{4+}	0.0042
OH^-	0.0042

a) Write the balanced equilibrium equation to show the ionisation of ammonia in water. **1**

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b) Determine the value of K for the equilibrium in part a) at 298 K. **2**

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Question 30 is continued on the next page

c) Using K, determine the mass of ammonium chloride that must be added to a 2.0 L of 0.10 mol L^{-1} ammonia to form a buffer with a pH of 9.00 at 298 K? Assume the addition of ammonium chloride does not change the volume of the solution. **5**

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End of Question 30

Question 31 (8 marks)

A primary standard was prepared by dissolving 16.45 g of sodium carbonate in 2.00 L of distilled water. This solution was then used to standardise a solution of hydrochloric acid. An average titre volume of 12.93 mL of the sodium carbonate solution was required to neutralise 20.00 mL of the hydrochloric acid.

The hydrochloric acid was then used to calculate the concentration of sodium hydroxide in a household cleaning solution. A 10.00 mL sample of the cleaning solution was diluted by adding distilled water up to a volume of 250.0 mL in a volumetric flask. Five 20.00 mL aliquots of the diluted cleaner was titrated against the hydrochloric acid.

The following results were collected.

Titre	Volume of HCl added (mL)
1	18.00
2	17.80
3	17.51
4	17.72
5	17.76

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Calculate the concentration of the sodium hydroxide in the original cleaning solution.

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Question 31 is continued on the next page

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End of Question 31

Question 32 (5 marks)

The table below features the molecular masses and boiling points of five different organic compounds.

Organic Compound	Molecular Mass (g/mol)	Boiling Point (^{o}C)
Hexane	86.18	36
Pentan-1-ol	88.18	117
Butanoic acid	88.11	163.5
Butanamide	87.12	216
Pentanal	86.13	74

Account for the differences in boiling points of the above compounds. **5**

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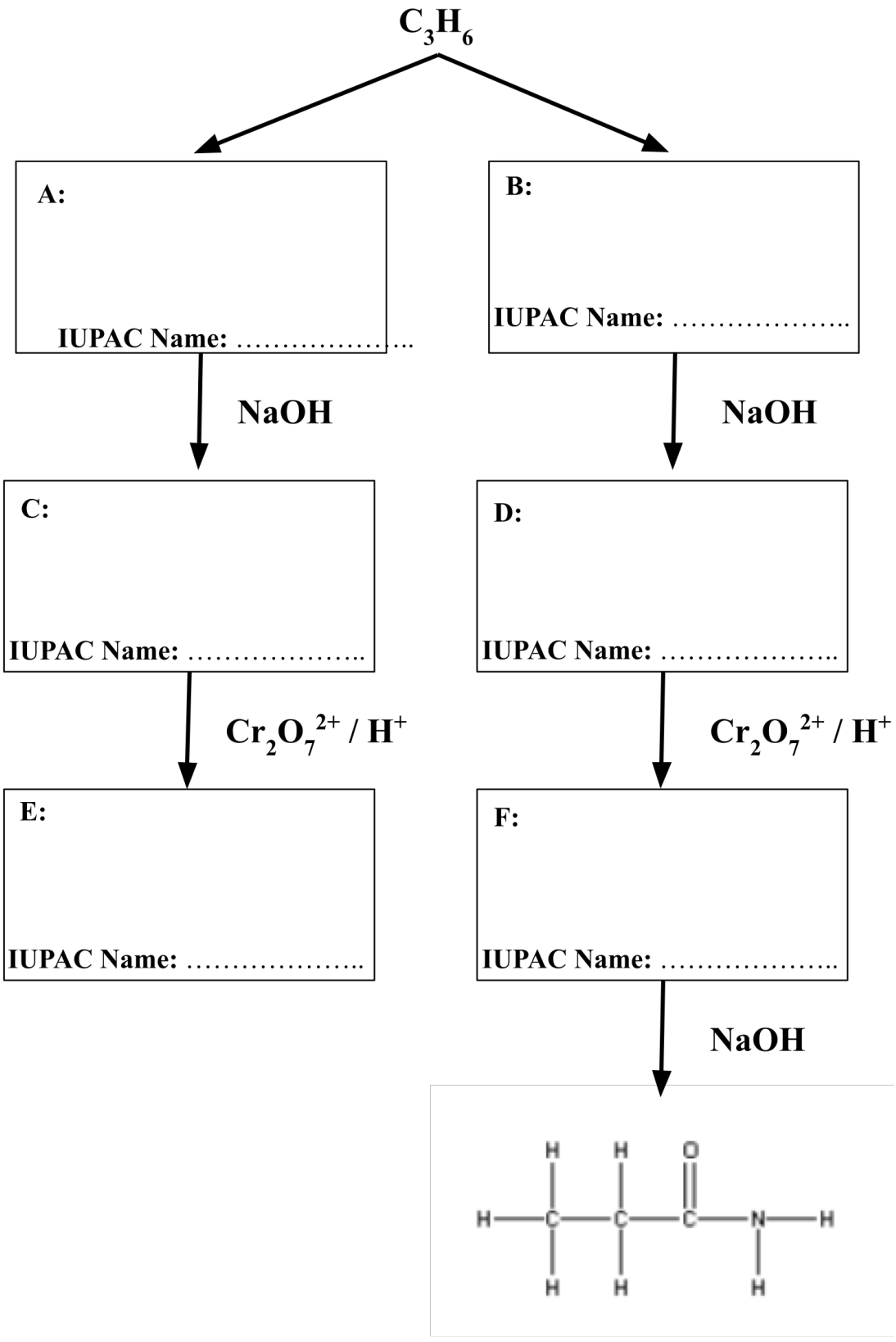
Question 33 (6 marks)

A sequence of chemical reactions is shown below. Complete the flow chart by providing the structural formulae and names for compounds A, B, C, D, E and F in the boxes provided.



Question 34 (7 marks)

Calculate the pH of the solution formed when 15.0 mL of 0.050 mol L^{-1} NaOH is added to 35.0 mL of 0.0250 mol L^{-1} benzoic acid (C_6H_5COOH, $K_a = 6.3 \times 10^{-5}$). **7**

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End of Exam

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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.

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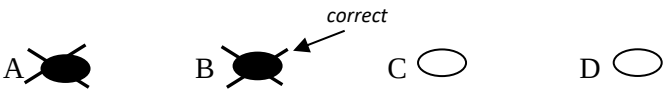


1 Which of the following is a valid way of converting an alkene into an alkane?

A. React with hydrogen gas

B. React with water

C. React with concentrated sulfuric acid

D. Shine with ultra violet light

Alkene to alkane is an addition reaction (hydrogenation).

2 Which of the following statements is NOT an important feature of a primary standard solution?

A. Stable

B. Absorbs moisture from air

C. Known chemical formula

D. High molecular mass

Absorbing moisture from the air would lead to an inaccurately determined number of moles of the solid that is used to make the standard and therefore the calculated concentration of the standard would be inaccurate as well.

3 A student attempts to conduct a titration to determine the concentration of NaOH against a primary standard. They plan to set up the burette with the NaOH and the conical flask with the primary standard. Based on this plan, which of the following matches the correct rinsing solution to the correct equipment?

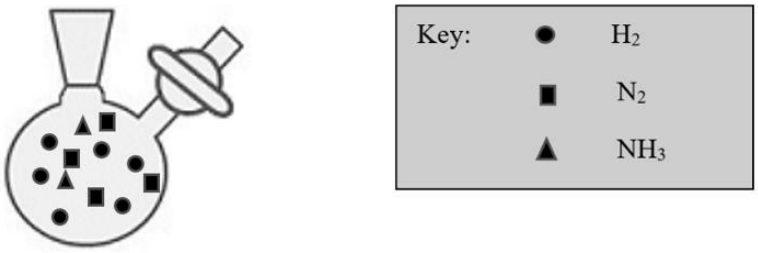
	Burette	**Conical flask**	**Pipette**
A.	NaOH	Distilled water	Primary standard
B.	Distilled water	Primary standard	NaOH
C.	NaOH	NaOH	Distilled water
D.	NaOH	Primary standard	Primary standard

Transfer equipment must be rinsed with the solution to be transferred. This ensures a known number of moles is measured and transferred. Other equipment e.g. conical flask, volumetric flask is rinsed with distilled water to not introduce unknown number of moles of reactant.

4 The reaction between hydrogen and nitrogen gas to form ammonia is reversible and will come to equilibrium under suitable conditions.

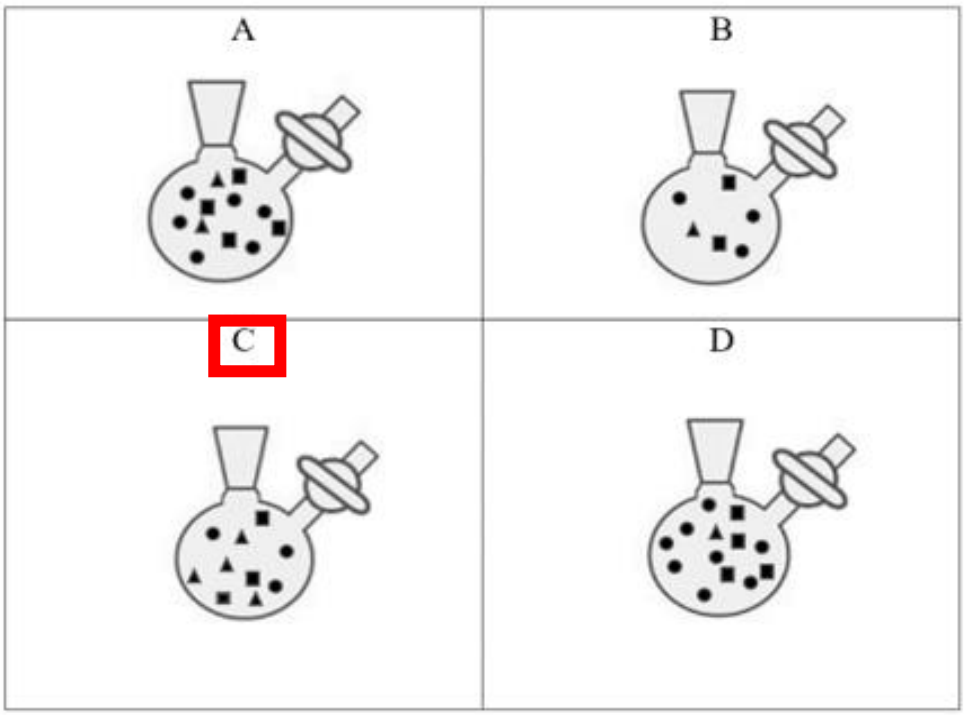
$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)} \quad \Delta H = -92 \text{ kJ mol}^{-1}$$

The diagram below represents a mixture of the relevant gases at equilibrium at 25°C.



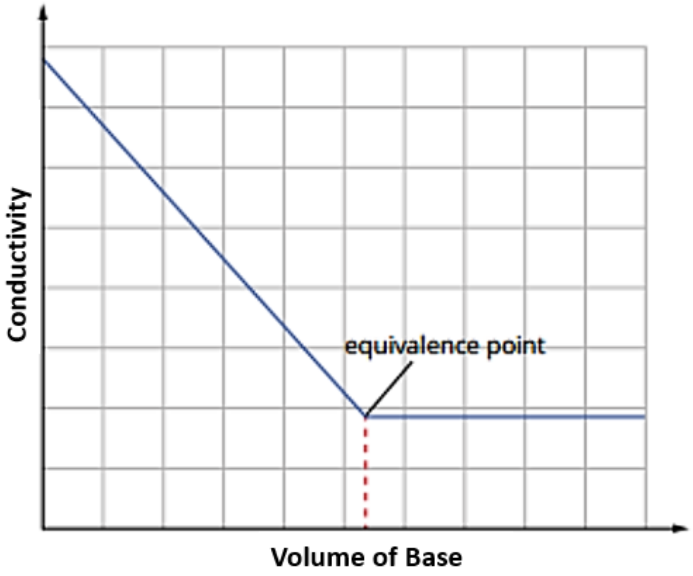
The flask was cooled and the system re-established equilibrium at a temperature of 4°C.

Which diagram best represents the composition of the flask at equilibrium?

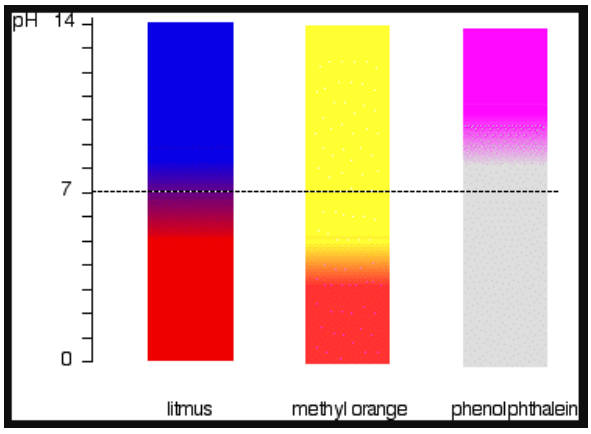


Temperature decrease ➔ exothermic forward reaction is favoured ➔ [ammonia] should increase; [nitrogen] and [hydrogen] should decrease

5 A conductivity titration experiment was conducted on a reaction between an acid and base. The graph below was generated from the results collected.



The diagram below shows the pH range of colour change for some indicators.



Which of the following would be an appropriate choice of indicator for a titration involving the same acid and base?

A. Litmus

B. Methyl orange

C. Phenolphthalein

D. Any indicator

The conductivity curve is indicative of a strong acid and weak base titration ➔ equivalence point would be below pH 7 ➔ indicator colour change should match this

6 A student carried out an investigation into the behaviour of hydrated copper sulfate when it was heated in an open test tube. The following extract is from the rough notes written by the student:

1. ***A sample of hydrated copper sulfate was put into a test tube. The copper sulfate was a bright blue solid.***
2. ***The test tube was heated carefully using a Bunsen Burner flame. When heated, the copper sulfate gave off a vapour.***
3. ***The solid was allowed to cool. When cooled, the solid was white.***
4. ***Water was added to the solid. The solid became bright blue and the test tube became warm.***

Based on the information given, what should the student conclude?

A. The procedure shows a reversible reaction.

B. The procedure shows a static equilibrium.

C. Copper sulfate combusts when heated.

D. Copper sulfate is an ionic substance.

The experiment shows a dynamic equilibrium.

7 Which of the following equations shows the first species in the reaction acting as a Bronsted-Lowry base but not an Arrhenius base?

A. $HCl_{(aq)} + H_2O_{(l)} \rightarrow Cl^-_{(aq)} + H_3O^+_{(aq)}$

B. $OH^-_{(aq)} + H_3O^+_{(aq)} \rightarrow 2H_2O_{(l)}$

C. $CH_2C_6H_5^-{}_{(aq)} + NH_{3(aq)} \rightarrow CH_3C_6H_{5(aq)} + NH_2^-{}_{(aq)}$

D. $HCl_{(aq)} + NH_{3(aq)} \rightarrow NH_4^+{}_{(aq)} + Cl^-_{(aq)}$

BL bases accept protons i.e #H atoms in formula increased by one. Arrhenius bases have OH^- in their structure.

8 Which combination of reagents would have the highest expected temperature rise after mixing?

A. 200 mL 0.1 mol L^{-1} HNO_3
300 mL 0.1 mol L^{-1} NaOH
LR is HNO_3 ➔ n(water produced) = 0.2 x 0.1 = 0.2 mol
q = mcΔT
0.2 x molar heat of neutralisation = mcΔT
0.2 x molar heat of neutralisation = (0.2+0.3)cΔT
$$\Delta T = \frac{0.2}{0.5} \text{ x } \frac{\text{molar heat of neutralisation}}{c}$$
$$= 0.4 \frac{\text{molar heat of neutralisation}}{c}$$

B. 400 mL 0.1 mol L^{-1} HNO_3
600 mL 0.1 mol L^{-1} NaOH
LR is HNO_3 ➔ n(water produced) = 0.4 x 0.1 = 0.4 mol
q = mcΔT
0.4 x molar heat of neutralisation = mcΔT
0.4 x molar heat of neutralisation = (0.4+0.6)cΔT
$$\Delta T = \frac{0.4}{1} \text{ x } \frac{\text{molar heat of neutralisation}}{c}$$
$$= 0.4 \frac{\text{molar heat of neutralisation}}{c}$$

C. 150 mL 0.2 mol L^{-1} HNO_3
150 mL 0.2 mol L^{-1} NaOH
n(water produced) = 0.15 x 0.2 = 0.3 mol
q = mcΔT
0.3 x molar heat of neutralisation = mcΔT
0.3 x molar heat of neutralisation = (0.15+0.15)cΔT
$$\Delta T = \frac{0.3}{0.3} \text{ x } \frac{\text{molar heat of neutralisation}}{c}$$
$$= \frac{\text{molar heat of neutralisation}}{c}$$ **➔ largest temperature change!**

D. 250 mL 0.1 mol L^{-1} CH_3COOH
250 mL 0.1 mol L^{-1} NaOH
n(water produced) = 0.25 x 0.1 = 0.25 mol
q = mcΔT
0.25 x molar heat of neutralisation = mcΔT
0.25 x molar heat of neutralisation = (0.25+0.25)cΔT
$$\Delta T = \frac{0.25}{0.50} \text{ x } \frac{\text{molar heat of neutralisation}}{c}$$
$$= 0.5 \frac{\text{molar heat of neutralisation}}{c}$$

9 Calcium nitrate thermally decomposes to form calcium oxide, nitrogen dioxide and oxygen. The table below lists the thermochemical data for this reaction.

	$Ca(NO_3)_{2(s)}$	$CaO_{(s)}$	$NO_{2(g)}$	$O_{2(g)}$
$\Delta_f H^o$ (kJ mol^{-1})	-938	-635	33	0
$\Delta_f S^o$ (J mol^{-1} K^{-1})	193	38	240	205

At what temperature will the reaction change from being non-spontaneous to spontaneous?

A. 863 ºC

B. 863 K

C. 8.63 ºC

D. 8.63 K

$Ca(NO_3)_2$ ➔ $CaO + 2NO_2 + ½O_2$

$\Delta H = [(-635)+2(33)+1/2(0)] – [(-938)]$

$\Delta S = [(38)+2(240)+1/2(205)]-[(193)]$ ← convert to kJ before substituting into ΔG

$\Delta G = \Delta H – T\Delta S = 0$

$T = \Delta H/\Delta S$

10 What is the temperature of the resultant solution after 25.0 mL of 1.0 mol L^{-1} sulfuric acid was mixed with 40 mL of 1.5 mol L^{-1} lithium hydroxide? Assume that $\Delta H_{neutralisation}$ = -55.9 kJ mol^{-1} and the initial temperature of each reactant was 25ºC.

A. 30ºC

B. 35ºC

C. 37ºC

D. 42ºC

$Ba(OH)_2 + 2HNO_3$ ➔ $Ba(NO_3)_2 + 2H_2O$

$n(Ba(OH)_2) = 25x10^{-3}x1.0 = 0.025$

$n(HNO_3) = 40x10^{-3}x1.5 = 0.06$

therefore, LR is $Ba(OH)_2$

$n(H_2O) = 0.025x2 = 0.05$

$q = 55.9 \times 0.05 = 2.795$ kJ = 2795 J

$2795 = (25+40)x10^{-3}x4.18x10^{-3}x\Delta T$

$\Delta T = 10.28…$

Final T = 25 + 10.28…

11 Ascorbic acid ($H_2C_6H_6O_6$) has a K_a of 7.9×10^{-5}. Carbonic acid (H_2CO_3) has a K_a of 4.5×10^{-7}.

Which of the following 0.1 mol L^{-1} solutions would have the highest pH?

A. $H_2C_6H_6O_6$

B. H_2CO_3

C. $NaHC_6H_6O_6$

D. $NaHCO_3$

Carbonic acid has smaller K ➔ weaker acid ➔ stronger conjugate base ➔ salt containing this will be more basic ➔ higher pH

12 Which of the following compounds would have the highest pH?

A. propan-1-amine

B. propanamide

C. propanoic acid

D. propan-1-ol

Amines are basic; amides and alkanols close to neutral; carboxylic acids are acidic

13 Which of the following is the correct order of the compounds from least soluble to most soluble in water?

A. chloroethane, prop-1-ene, ethanol, propan-1-ol

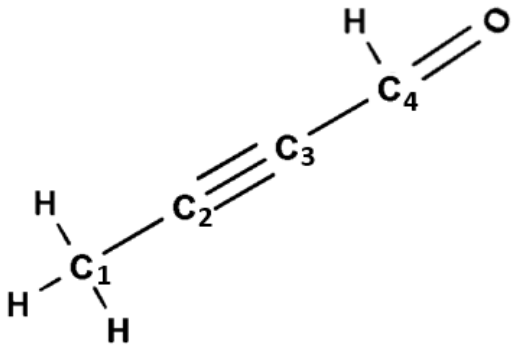
B. butane, chloropropane, butan-1-ol, propan-1-ol

C. but-2-ene, butanoic acid, butane, butan-2-ol

D. butanoic acid, butan-1-ol, but-2-ene, butane

For solubility in water:
alkane > haloalkane > longer chain alcohol > smaller chain alcohol

14 The structure of a compound is shown below. Its carbon atoms are labelled 1 to 4.



Which of the following correctly describes the shape around each carbon atom?

	Carbon 1	**Carbon 2**	**Carbon 3**	**Carbon 4**
A.	Linear	Linear	Linear	Tetrahedral
B.	Tetrahedral	Linear	Linear	Tetrahedral
C.	Trigonal Planar	Linear	Linear	Tetrahedral
D.	Tetrahedral	Linear	Linear	Trigonal Planar

Based on VSEPR:
Around C atom that only has 4 single bonds ➔ tetrahedral
Around C atom that has a triple bond ➔ linear
Around C atom that has a double and two single bonds ➔ trigonal planar

15 A sample of vinegar has a density of 1.01 g mL^{-1} and contains 3.00% by mass of ethanoic (acetic) acid. What volume of 0.500 mol L^{-1} potassium hydroxide is required to neutralise 25.0 mL of the vinegar?

A. 1.00×10^{-2} L

B. 1.26×10^{-2} L

C. 2.52×10^{-2} L

D. 3.03×10^{-2} L

m(vinegar) = 25.0 x 1.01

m(acetic acid) = m(vinegar) x 3%

n(acetic acid) = m(acetic acid)/(12.01x2+1.008x4+16x2)

n(KOH) = n(acetic acid)

v(KOH) = n(KOH)/0.5

16 Which of the following lists show the solutions in order from lowest to highest electrical conductivity?

A. 0.05 mol L^{-1} acetic acid; 0.05 mol L^{-1} hydrochloric acid; 0.1 mol L^{-1} sodium hydroxide; 0.1 mol L^{-1} calcium hydroxide

B. 0.1 mol L^{-1} calcium hydroxide; 0.1 mol L^{-1} sodium hydroxide; 0.05 mol L^{-1} hydrochloric acid; 0.05 mol L^{-1} acetic acid

C. 0.1 mol L^{-1} sodium hydroxide; 0.1 mol L^{-1} calcium hydroxide; 0.05 mol L^{-1} hydrochloric acid; 0.05 mol L^{-1} acetic acid

D. 0.05 mol L^{-1} acetic acid; 0.05 mol L^{-1} hydrochloric acid; 0.1 mol L^{-1} calcium hydroxide; 0.1 mol L^{-1} sodium hydroxide

Higher concentration of ions ➔ higher electrical conductivity

Stronger base/acid ➔ higher concentration of ions in solution ➔ higher electrical conductivity

17 A solution of crystalline diprotic oxalic acid ($H_2C_2O_4.2H_2O$) is prepared by dissolving 12.6 g of the acid in 4.00 L of water. A 20.0 mL volume of this solution is required to completely neutralise 36.0 mL of a potassium hydroxide solution. What is the concentration of the potassium hydroxide solution?

A. 0.0194 mol L^{-1}

B. 0.0139 mol L^{-1}

C. 0.0389 mol L^{-1}

D. 0.0278 mol L^{-1}

n(acid in 4L) = 12.6/(2x12.01+6x1.008+6x16)

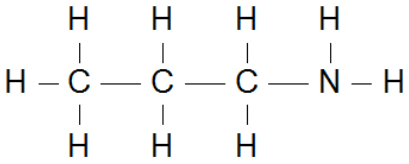
n(acid in 20mL) = n(acid in 4L) x 20/4000

n(KOH) = n(acid in 20mL) x 2

c(KOH) = n(KOH)/0.036

18 Under appropriate conditions glucose will react with yeast to produce compound X and carbon dioxide gas. Compound X can then be oxidised with heat to produce compound Y.

Compound Y is then reacted with the compound shown below.



Which of the following is the preferred IUPAC name of the final product formed?

A. *N*-ethylpropanamide

B. *N*-ethylpropanamine

C. *N*-propylethanamide

D. *N*-propylethanamine

Compound X must be ethanol and therefore compound Y is ethanoic acid. Reacting carboxylic acid with amine produces an amide.

19 A 0.30 g sample of propan-2-ol was burned in a spirit burner placed under an open flask which contained 100 g of water initially at 25ºC. When heating was finished it was determined that 45% of the heat produced was lost to the environment. The theoretical enthalpy of combustion of propan-2-ol is -2644 kJ mol^{-1}.

What was the final temperature of the water?

A. 32ºC

B. 39ºC

C. 42ºC

D. 57ºC

n(propanol) = 0.30/(3x12.01+8x1.008+16)

q(theoretical) = 2644 x n(propanol) x 1000 J

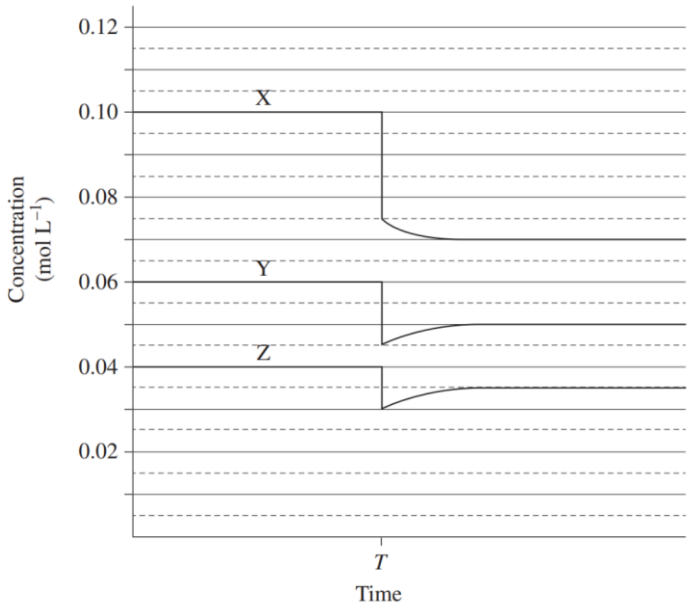
q(experimental) = q(theoretical) x (100-45)%

q(experimental) = $100x10^{-3}x4.18x10^{-3}x\Delta T$

ΔT = 17

Final T = 25 + 17

20 Three gases X, Y and Z were mixed in a closed container and allowed to reach equilibrium. A change was imposed at time T and the equilibrium was re-established. The concentration of each gas is plotted against time.



Which of the values below is closest to the equilibrium constant value K for the reaction if X is considered to be the reactant?

A. 2.4×10^{-2}

B. 0.24

C. 42

D. 255

Species must be in 1:1:1 ratio due to the change in concentration after T being the same i.e. 0.01 mol/L). Therefore the equilibrium is X ⇌ Y + Z so K = [Y][Z]/[X] = (0.06 x 0.04)/0.1

Section II

80 marks

Show all relevant working in questions involving calculations.

Question 21 (4 marks)

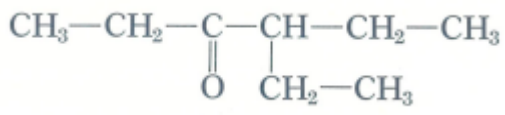
a) 2,2-diethylbutane is the incorrect name for a compound. Explain why this name is incorrect and give the correct name. **2**

1 mark. Correctly name compound as 3-ethyl-3-methylpentane

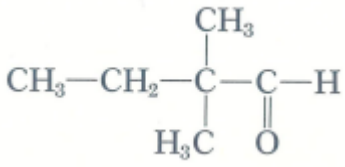
1 mark. Because the longest C chain is not identified which is 5 carbons

Note: Draw out the full structural formula and label the C atoms!

b) Name the following two compounds: **2**



1 mark. 4-ethylhexan-3-one



1 mark. 2,2-dimethylbutanal

Question 22 (2 marks)

Identify the conjugate acid of the following species.

a) HPO_4^{2-} $H_2PO_4^-$ **1**

……...

b) O^{2-} OH^- **1**

……...

Question 23 (4 marks)

Complete the table below to outline ONE advantage and ONE disadvantage for each fuel category. **4**

Type of fuel	Advantages	Disadvantages
Fossil Fuel	**1 mark.** More energy produced / gram of fuel used	**1 mark.** Non-renewable energy source; takes millions of years to recreate
Biofuel	**1 mark.** Less energy produced / gram of fuel used	**1 mark.** Renewable energy source; created from plants which take much less time to regenerate

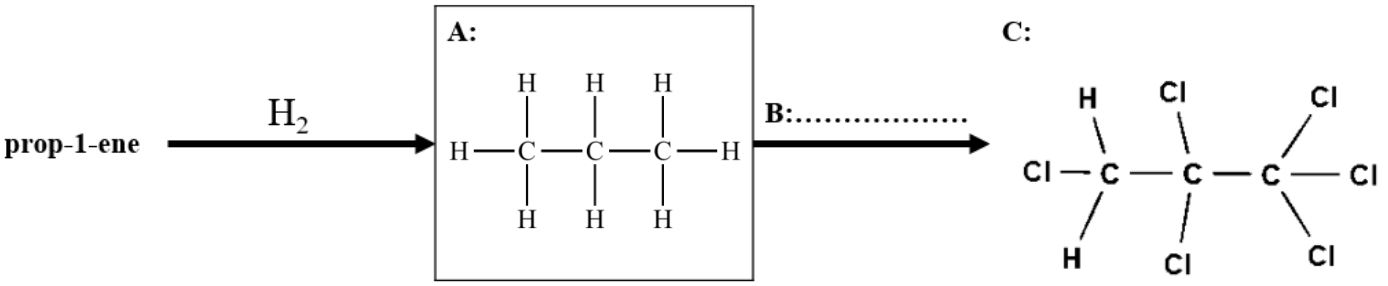
Markers comments:

- Outline means we provide more detail than a one-word answer!
- 2/4 mark awarded if you gave vague and/or one-word answers that were correct
- Vague statements were not accepted, eg. Fossils fuels are more efficient. How?

Question 24 (4 marks)

Complete the flow chart below by: **4**

- identifying the structural formula and name of compound A
- identifying reagent/conditions B
- identifying name of compound C



1 mark. Write IUPAC name for A - propane

1 mark. Draw structural formula of propane

1 mark. Identify reagent/conditions B – Cl_2 / HCl and UV light. You needed BOTH to get this mark

1 mark. Write IUPAC name for C – 1,1,1,2,2,3-hexachloropropane

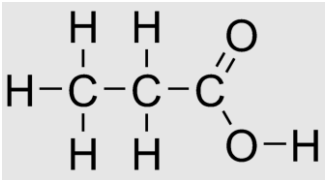
Question 25 (7 marks)

A student completely neutralised a 50 mL aliquot of 0.1 mol L^{-1} NaOH using a 50 mL aliquot of 0.1 mol L^{-1} HCl. They were then surprised to discover that 50 mL of 0.1 mol L^{-1} propanoic acid also neutralised the same volume and concentration of NaOH solution.

a) Explain why the same volume of both acids was required to neutralise the NaOH solution, even though one was strong and one was weak. **3**

General comments:

- Poorly done question – please review your understanding of neutralisation reactions
- Most were only able to access one mark; very few achieved full marks
- Mark deductions for incorrect chemistry (see x and 'incorrect chemistry' or 'mark deduction') e.g.
    - Many students had incorrect chemical formula for propanoic acid – if in doubt draw it out! And count the bonds around C – should always be 4! Strange variations accepted but the total number of C/H/O had to be correct.



    - Several had an equilibrium arrow for their neutralisation reaction – neutralisation reactions go to completion!

(e) 1mk shows understanding of the weak acid ionisation equilibrium being driven forward due to presence of base e.g. *Although weak acids partially ionise in water, when a base is added the hydroxide ions react with hydronium ions from the acid and this continues to drive the ionisation of the weak acid to completion.*

(n) 1mk links this to the number of hydronium ions that will be consumed in a neutralisation reaction with strong base e.g. *Therefore, the same volume of a monoprotic acid with the same concentration will produce the same number of hydronium ions for the neutralisation reaction.*

(s) 1mk links to stoichiometry of BOTH neutralisation reactions e.g. *Since both neutralisation reactions have a 1:1 n(acid):n(base) stoichiometry, this means the same n(acid)/n(hydronium ions) is required for the same n(base) as well i.e. same volume required.*

b) The student then compared the pH of the NaOH solution neutralised by the HCl (Reaction X) with the pH of the NaOH solution neutralised by the propanoic acid (Reaction Y) and found that they were different. Using relevant chemical equation(s), account for the difference in pH of the two solutions and identify which had the higher pH. **4**

General comments:

- Wide range of marks
- Again, mark deductions for incorrect chemistry e.g. excess of NaOH from the neutralisation reaction with propanoic acid => excess OH-
- Check you have actually answered the question! Clearly asks you to **identify** which had the higher pH not only stating which will be neutral or basic.
- Insufficient reasons for pH of reaction X or Y e.g. strong acid and strong base neutralisation therefore reaction X will be neutral
- Students that did not do any of the below may have been able to access 1 mark if they included both neutralisation reaction equations and had no other deductions
- Allowed for mistake carried (M.C.) due to incorrect formula of propanoic acid from part a)

(I) 1mk explicitly identifies reaction with higher pH e.g. Reaction Y would have the resultant solution with the higher pH

(X) 1mk accounts for pH of reaction X e.g. Reaction X involves a strong acid and strong base resulting in a neutral salt i.e. solution will have pH of 7

(Y) 1mk accounts for pH of reaction Y e.g. Reaction Y involves a weak acid and strong base resulting in a basic salt i.e. solution will have pH > 7

(C) 1mk provides correct hydrolysis equation e.g. This is because the anion of the salt is the conjugate base of a weak acid and is able to hydrolyse water in the following equation.

$$C_3H_5O_2{}^-{}_{(aq)} + H_2O_{(l)} \leftrightarrow C_3H_6O_{2(aq)} + OH^-{}_{(aq)}$$

Question 26 (4 marks)

Hydrogen iodide gas decomposes to form hydrogen gas and iodine gas as indicated in the reaction below. Hydrogen iodide and hydrogen are colourless gases and iodine is a purple gas.

$$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$$

The equilibrium constant (K_{eq}) for this reaction is 2.18×10^{-2} at 490°C.

a) 3.085 g of hydrogen iodide was placed in a 200 mL flask and the temperature of the system was raised to 490ºC. The concentration of iodine gas after a minute was found to be 0.0274 mol L^{-1}. Using calculations, determine whether this system is at equilibrium. **3**

1 mark. Calculate moles and concentration of HI (using n=m/MM and c=n/V)

n(HI) = 3.085 / (1.008 + 126.9) = 0.024119… mol

[HI] = 0.024119 / 0.2 = 0.120595… mol L^{-1}

1 mark. Construct ICE table to find the concentrations of species at equilibrium

	$2HI_{(g)}$	⇌	$H_{2(g)}$	+	$I_{2(g)}$
I	0.120595		0		0
C	-2x		+x		+x
E	0.120595-2x		0.0274		0.0274

[HI] at equilibrium = 0.1205945 – (2 x 0.0274) = 0.0657945 … mol L^{-1}

1 mark. Calculate Q, compare value to K and determine whether system is at equilibrium

$Q = [H_2][I_2] / [HI]^2$

$Q = (0.0274)(0.0274) / 0.0657945^2 = 0.173429$ …

Q does not equal K, therefore the system is not at equilibrium

b) What observation could be made to qualitatively determine if the system had reached equilibrium? **1**

1 mark. The <u>colour will stop changing</u> since the concentration of all species ceases to change

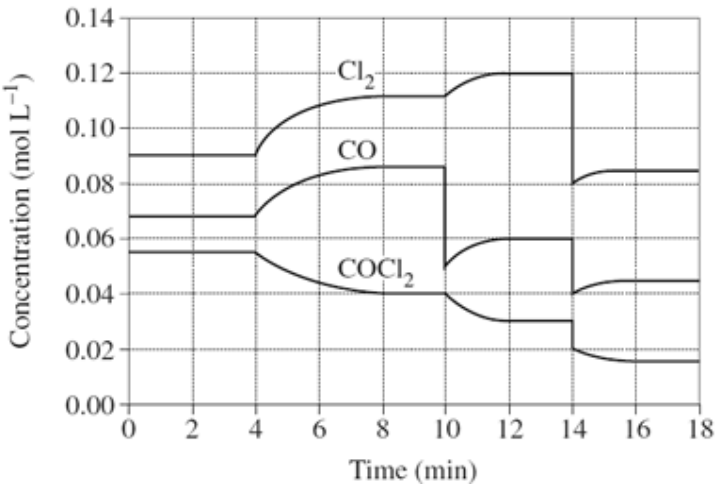
Note: You did need to state that the colour stops changing. Saying that the colour would become a light purple is too vague – equilibrium is only reached when all concentrations become stable

Question 27 (7 marks)

Phosgene ($COCl_2$) is a poisonous gas that dissociates at high temperatures into two other poisonous gases, carbon monoxide and chlorine.

$$COCl_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2(g)} \qquad \Delta H = +108 \text{ kJ mol}^{-1}$$

The following shows the concentration of the species of this reaction as three changes were made to the system.



a) Identify the change imposed on the system at 4 min. **1**

Temperature increased 1Mark

b) Using collision theory, explain the change in concentrations of the species between 4 min and 8 min. **3**

A temperature increase will increase the kinetic energy of the particles increasing the likelihood of successful collisions. 1 Mark

An increase in temperature will cause an increase in BOTH the forward and reverse rates of reaction. 1 Mark

Since the forward reaction is exothermic its Activation Energy is greater the activation energy for the reverse rate of reaction. With the increase in temperature there are relatively more particles that now have sufficient energy to overcome the E_A in the forward direction, relative to the increase in the reverse direction. 1 Mark

Examiners comments Some students attempted to answer this question in terms of Le Chatelier's Principle, the question specifically asks for collision theory. Need to be aware that reverse reaction also increased.

a) Phosgene at 105.0 kPa is allowed to come to equilibrium in a fixed volume at 527 K. The equilibrium pressure of carbon monoxide at this temperature is measured to be 39.0 kPa. Using concentrations of the species in mol L^{-1}, calculate the equilibrium constant K for this system. **3**

Using the Ideal Gas Law

As PV = nRT then n/V = P/RT which is concentration in mol L^{-1}

[CO] = 39.0/ 8.314 x 527 = 0.0089 molL^{-1} 1mk

[Cl_2] = 0.0089 molL^{-1} 1 mk

Equilibrium $COCl_2$ pressure = 105.0 - 39.0 = 66.0 kPa (many students failed to realise this)

[$COCl_2$] = 66.0 / 8.314 x 527 = 0.015 molL^{-1} 1 mk

K= [CO][Cl_2] / [$COCl_2$] = $(0.0089)^2$ / 0.015 = 5.26 x 10^{-3}

Question 28 (5 marks)

Using calculations, compare the molar solubility of silver phosphate in water with its solubility in 0.100 mol L^{-1} silver nitrate (both at 25°C). **5**

In water

$8.89 \times 10^{-17} = [Ag^+]^3[PO_4^{3-}]$ 1 mk

Let $[Ag_3PO_4] = x$

$[Ag^+] = 3x$ $[PO_4^{3-}] = x$

$8.89 \times 10^{-17} = (3x)^3 \times x$

$27x^4 = 8.89 \times 10^{-17}$

$x = 4.26 \times 10^{-5}$ mol L^{-1} 1 mk

In silver nitrate solution

Assume $[Ag^+] = 0.100$ (as $x << 0.100$) 1 mk

$8.89 \times 10^{-17} = [0.100]^3[PO_4^{3-}]$

$[PO_4^{3-}] = 8.89 \times 10^{-14}$ mol L^{-1} 1 mk

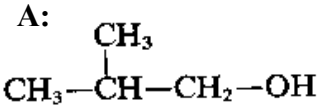
Silver phosphate is more soluble in water than in 0.100 mol L^{-1} silver nitrate. 1mk

This statement needed as question asks for comparison of solubility.

Question 29 (9 marks) moved earlier

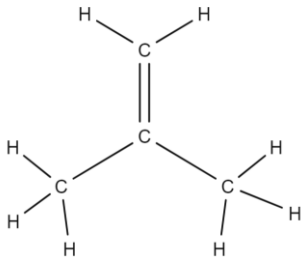
The following represents a 2-step conversion reaction:

A:



IUPAC name: 2-methylpropan-1-ol

B: Concentrated Sulfuric Acid

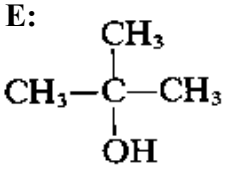


IUPAC name: 2-methylpropan-1-ene

NB check that all carbons in structural formula have 4 bonds

D: H_2O / dilute acid

E:



IUPAC name: 2-methylpropan-2-ol

a) Complete the flow chart above by naming compounds A, C and E and reagents B and D and providing the structural formula for compound C in the spaces provided. **5**

b) Compounds A and E in the above reaction can be considered isomers of one another. What type of isomers are they? **1**

Positional

c) Name a chemical reaction that could be used to distinguish between compounds A and E. **1**

Oxidation

d) Identify one hazard when carrying out first hand investigations with alcohols and suggest one precaution that can be taken. **2**

Valid hazard identified 1mk e.g. alcohols are flammable.

Valid precaution which is related to hazard 1 mk e.g. keep alcohols away from ignition sources and naked flames.

Question 30 (8 marks)

Ammonia ionises in water to a small extent. At 298 K, the equilibrium concentrations of the relevant species are shown in the table below.

Species	**Concentration (mol L^{-1})**
NH_3	0.980
NH_4^+	0.0042
OH^-	0.0042

a) Write the balanced equilibrium equation to show the ionisation of ammonia in water. **1**

$$NH_{3\,(aq)} + H_2O_{\,(l)} \leftrightarrow {NH_4}^+_{(aq)} + {OH^-}_{(aq)}$$

b) Determine the value of K for the equilibrium in part a) at 298 K. **2**

1 mk $K = \frac{[NH_4^+][OH^-]}{[NH_3]}$

1 mk $= \frac{[0.0042][0.0042]}{[0.980]} = 1.8 \times 10^{-5}$

Question 30 is continued on the next page

c) Using K, determine the mass of ammonium chloride that must be added to a 2.0 L of 0.10 mol L^{-1} ammonia to form a buffer with a pH of 9.00 at 298 K? Assume the addition of ammonium chloride does not change the volume of the solution. **5**

pOH = 14.00 – 9.00 = 5.00

$[OH^-] = 10^{-5} = 0.00001$ mol L^{-1} **1 mark**

$$NH_{3\,(aq)} + H_2O_{\,(l)} \leftrightarrow {NH_4}^+_{(aq)} + OH^-_{(aq)}$$

$$\frac{[NH4+][0.00001]}{[0.10]} = 1.8 \times 10^{-5}$$ **1 mark correct substitution**

Since K is very small, x must also be very small. Therefore, assume NH3 conc at eqm is same as initial NH3 conc = 0.10. **1 mark NH_3 conc assumption**

$$x = [{NH_4}^+] = [NH_4Cl] = \frac{[1.8 \times 10^{-5}x][0.10]}{[0.00001]} = 0.18 \text{ mol } L^{-1}$$

$n(NH_4Cl) = 0.18 \times 2.0 = 0.36\,mol$ **1 mark**

$m(NH_4Cl) = 0.36 \times (14.01 + 4 \times 1.008 + 35.45) = 19\,g$ **1 mark**

End of Question 30

Question 31 (8 marks)

A primary standard was prepared by dissolving 16.45 g of sodium carbonate in 2.00 L of distilled water. This solution was then used to standardise a solution of hydrochloric acid. An average titre volume of 12.93 mL of the sodium carbonate solution was required to neutralise 20.00 mL of the hydrochloric acid.

The hydrochloric acid was then used to calculate the concentration of sodium hydroxide in a household cleaning solution. A 10.00 mL sample of the cleaning solution was diluted by adding distilled water up to a volume of 250.0 mL in a volumetric flask. Five 20.00 mL aliquots of the diluted cleaner was titrated against the hydrochloric acid.

The following results were collected.

Titre	Volume of HCl added (mL)
1	18.00
2	17.80
3	17.51
4	17.72
5	17.76

Calculate the concentration of the sodium hydroxide in the original cleaning solution. **8**

General comments:

- Clarity in your working out has improved for most students
- Significant figures was targeted for this question i.e. mark deduction if final answer not 3s.f.
- Do not round your answers too early – no deductions for this but HSC may do so
- Did not deduct for not showing conversions (e.g. mL to L) but please make this a habit for HSC

Reaction 1: $Na_2CO_{3\ (aq)} + 2HCl_{(aq)} \rightarrow CO_{2_{(g)}} + 2NaCl_{(aq)} + H_2O_{(l)}$

Reaction 2: $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

- Did not require the above to access full marks – however, best practice is to include relevant chemical equations. Good to see most included the above with appropriate identifiers to reference back to throughout there working out.
- Careful, carbonate + acid DOES NOT produce carbonic acid + salt in an open system.

Question 31 is continued on the next page

Sample Answer

(a) n(Na_2CO_3 in 2.00 L) = 16.45 ÷ (22.99 x 2 + 12.01 + 16.00 x 3) = 0.1552.. mol

- Allowed for 16.45 ÷ 105.99 but you must SHOW ALL WORKING for the HSC

(b) [Na_2CO_3 in 2.00L] = 0.1552.. ÷ 2.00 = 0.07760… mol L^{-1}

In reaction 1,

(c) n(Na_2CO_3 req'd to neutralise HCl) = 0.07760… x 12.93 x 10^{-3} = 0.001003…mol

(d) n(HCl in 20 mL) = 0.001003…x 2 = 0.002006… mol **AND**

[HCl] = 0.002006… ÷ (20 x 10^{-3}) = 0.10033.. mol L^{-1}

In reaction 2,

(e) average v(HCl) = (17.80 + 17.72 + 17.76) ÷ 3 = 17.76 mL = 17.76 x 10^{-3} L

- Most students showed working this time but some still did not => not awarded mark

(f) n(HCl) = 17.76 x 10^{-3} x 0.10033.. = 0.00178… mol **AND**

n(NaOH in 20 mL aliquot of diluted cleaner) = 0.00178… x 1 = 0.00178… mol

Then one of the two options:

(g) n(NaOH in 250 mL of diluted cleaner) = 0.00178… x (250 ÷ 20) = 0.02225.. mol

(h) [NaOH in 10 mL sample] = 0.02225.. mol ÷ (10 x 10^{-3}) = 2.225… = 2.23 mol L^{-1}

OR

(g) [NaOH in 20 mL aliquot of diluted cleaner] = 0.00178…÷ (20 x 10^{-3})

= 0.089..mol L^{-1}

c1v1 = c2v2 => c1 = c2v2/v1

c1 = ?

v1 = 10 mL

c2 = 0.089..

v2 = 250 mL

(h) c1 = (0.089 x 250)/10 = 2.23 mol L^{-1}

- Allowed for 0.089 x 25 but you must SHOW ALL WORKING for the HSC

Question 32 (5 marks)

The table below features the molecular masses and boiling points of five different organic compounds.

Organic Compound	Molecular Mass (g/mol)	Boiling Point (°C)
Hexane	86.18	36
Pentan-1-ol	88.18	117
Butanoic acid	88.11	163.5
Butanamide	87.12	216
Pentanal	86.13	74

Account for the differences in boiling points of the above compounds. **5**

This question was marked holistically to gain full marks students needed to discuss the following points:

These compounds have similar molar masses, but the difference in boiling points is due to the degree and strength of intermolecular forces.

Hexane is a non-polar molecule hence the only intermolecular forces it displays are dispersion forces. Many students did not explicitly state that hexane is non-polar.

Pentanal is polar and has dipole-dipole attraction between molecules, which are stronger than dispersion forces and hence pentanal has a higher bp than hexane.

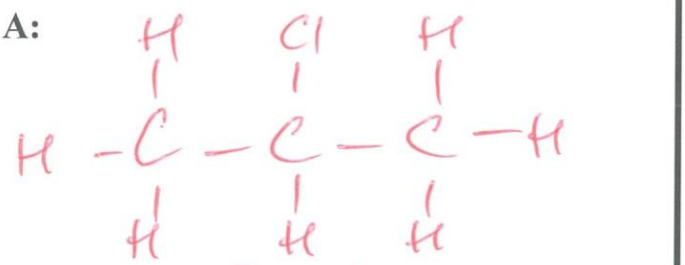
Pentanol, butanoic acid and butanamide all have hydrogen bonding between their molecules. The increase in boiling points between these compounds is due to an increased number of sites between molecules for the hydrogen bonding to occur, butanoic acid can form a dimer and butanamide can form a multimolecular lattice. Students incorrectly stated that the electronegativity difference is greater between carbon and oxygen than between hydrogen and oxygen or the difference between nitrogen and hydrogen is greater than between hydrogen and oxygen. Both these statements are incorrect.

Question 33 (6 marks)

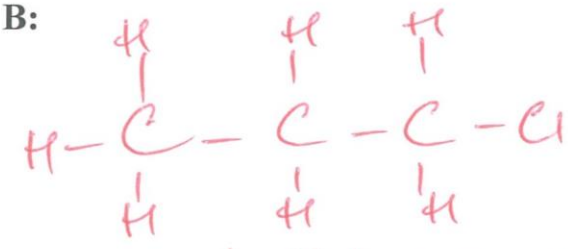
A sequence of chemical reactions is shown below. Complete the flow chart by providing the structural formulae and names for compounds A, B, C, D, E and F in the boxes provided.

C_3H_6

HCl HCl

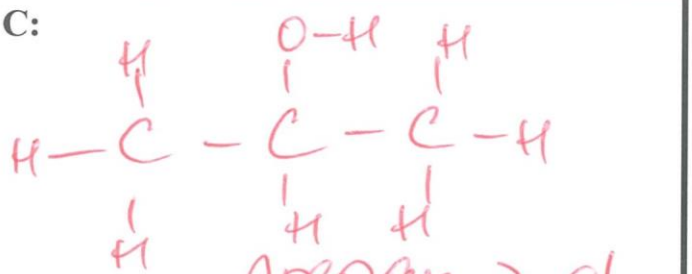
A: 

IUPAC name: 2-chloropropane

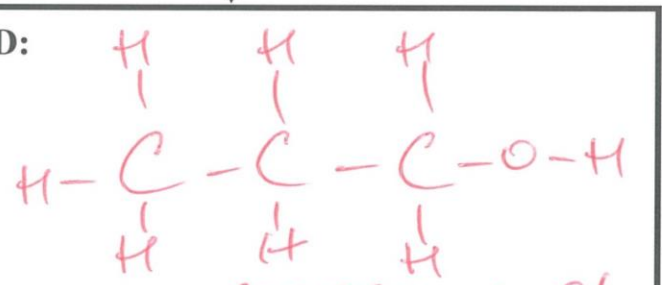
B: 

IUPAC name: 1-chloropropane

NaOH NaOH

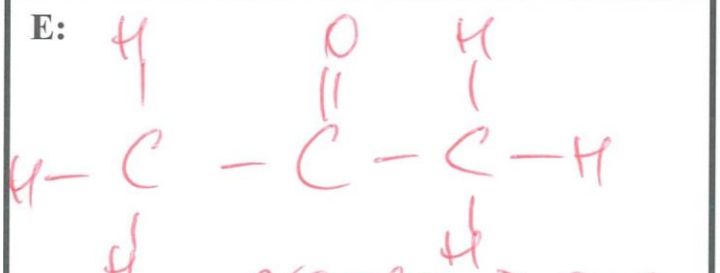
C: 

IUPAC name: propan-2-ol

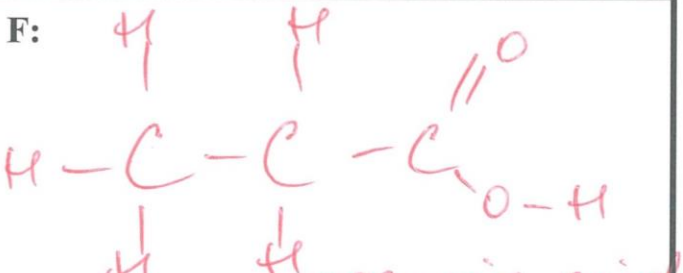
D: 

IUPAC name: propan-1-ol

$Cr_2O_7^{2-}$ / H^+ $Cr_2O_7^{2-}$ / H^+

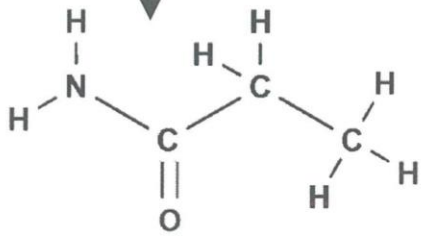
E: 

IUPAC name: propan-2-one or propanone

F: 

IUPAC name: propanoic acid

NH_3



Mark each - correct structure + name.

So half marks

Question 34 (7 marks)

Calculate the pH of the solution formed when 15.0 mL of 0.050 mol L^{-1} NaOH is added to 35.0 mL of 0.0250 mol L^{-1} benzoic acid (C_6H_5COOH, $K_a = 6.3 \times 10^{-5}$). **7**

$$NaOH_{(aq)} + C_6H_5COOH_{(aq)} \rightarrow NaC_6H_5COO_{(aq)} + H_2O_{(l)}$$

Note some students wrote this reaction as an equilibrium reaction, it is not.

n(NaOH) = 15 x 10^{-3} x 0.050 = 0.00075 mol

n(C_6H_5COOH) = 35 x 10^{-3} x 0.0250 = 0.000875 mol

1 mk to correctly calculate both these values

If we use all of NaOH, we would use n(C_6H_5COOH) = 0.00075 x 1 = 0.00075 mol which is less than what we have available i.e. 0.000875 mol

n(C_6H_5COOH left over) = 0.000875 - 0.00075 = 0.000125 mol **1 mk**

n(NaC_6H_5COO produced) = n($C_6H_5COO^-$) = 0.00075 x 1 = 0.00075 mol

total v(solution) = (35.0 + 15.0) x 10^{-3} = 0.050 L

The equation below is in equilibrium

$$C_6H_5COOH_{(aq)} + H_2O_{(l)} \leftrightarrow C_6H_5COO^-_{(aq)} + H_3O^+_{(aq)}$$

I	$\frac{0.000125}{0.050}$	$\frac{0.00075}{0.050}$	0
C	- x	+ x	+ x
E	$\frac{0.000125}{0.050} - x$	$\frac{0.00075}{0.050} + x$	x

Students need to recognise $[C_6H_5COO^-] \neq [H_3O^+]$ as benzoate ions present due to neutralisation reaction.

Since K is very small, x must also be very small so assume

$\frac{0.000125}{0.050} - x = \frac{0.000125}{0.050}$ and $\frac{0.00075}{0.050} + x = \frac{0.00075}{0.050}$ **1 mk**

$[C_6H_5COOH] = \frac{0.000125}{0.050} = 2.5 \times 10^{-3}$ **1 mk**

$[C_6H_5COO^-] = \frac{0.00075}{0.050} = 0.015$ **1 mk**

$$K = \frac{[C_6H_5COO^-][H_3O^+]}{[C_6H_5COOH]}$$

$$6.3 \times 10^{-5} = \frac{[x]\left[\frac{0.00075}{0.050}\right]}{\left[\frac{0.000125}{0.050}\right]}$$

$$x = [H_3O^+] = \frac{[6.3\times10^{-5}]\left[\frac{0.000125}{0.050}\right]}{\left[\frac{0.00075}{0.050}\right]} = 0.0000105\ldots \text{ mol L}^{-1}$$ **1 mk**

pH = -log(0.0000105…) = 4.98 **1 mk**

End of Exam

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