Student Number:……

Gosford High School
2019 Higher School Certificate
Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA-approved calculators may be used
- Three data sheets and a Periodic Table are provided at the back of this paper

Total marks: 100

Section I – 20 marks

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

Section II – 80 marks

- Attempt Questions 21-35
- 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

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

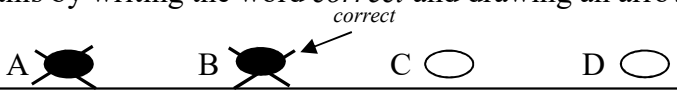
Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

If you 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 statements about acids and bases is FALSE?

A. Acids are able to produce hydrogen ions in aqueous solution.

B. A hydrogen ion attached to water forms a hydronium ion.

C. Bases are able to produce hydroxide ions in aqueous solution.

D. All oxides are basic.

2 Which one of the following compounds can be derived both from fossil fuels and from biomass materials?

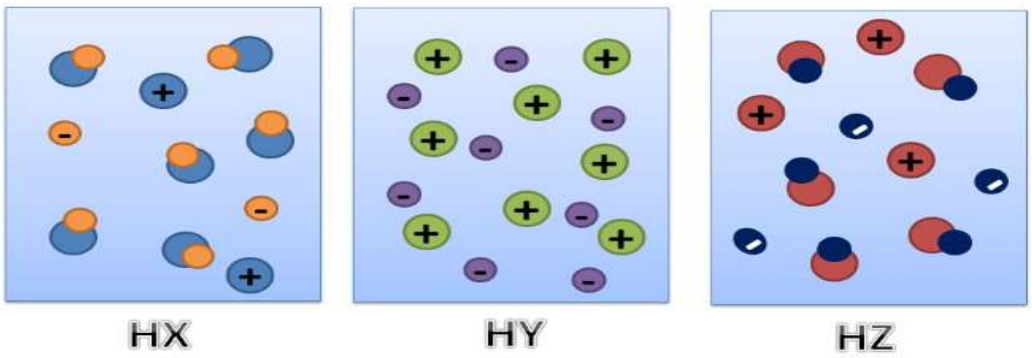
A. Ethanol

B. Octane

C. Glucose

D. Cellulose

3 Three solutions of acids, HX, HY and HZ, are represented by the following diagrams. For clarity, water molecules have not been shown.



The acids, in order of increasing acid strength, are

A. HX, HY, HZ

B. HZ, HX, HY

C. HX, HZ, HY

D. HY, HZ, HX

4 Consider the following organic compounds:

I – CH_3CH_2COOH

II – CH_3COCH_3

III – CH_3CH_2CHO

Which of the following statements is correct?

A. Compounds I, II and III belong to the same homologous series.

B. Compounds II and III have the same molecular formula.

C. Compound I has the lowest boiling point.

D. Compounds I and III would combine to form an ester and water in the presence of concentrated sulfuric acid.

5 Which of the following shows the product(s) of reaction of but-1-ene with water, in the presence of an acid catalyst?

A. Butan-1-ol only.

B. Butan-2-ol only.

C. A mixture of butan-1-ol and butan-2-ol.

D. A mixture of butan-1-ol and butan-4-ol.

6 The pH of a 0.0001 mol L^{-1} solution of a monoprotic acid was measured by a student and found to be 4.

What proportion of the acid molecules has been converted to ions?

A. 0%

B. 4%

C. 96%

D. 100%

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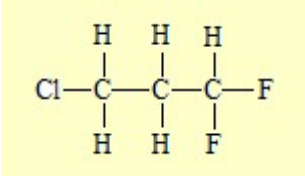


The compound shown above is

A. 2-chloro-3,3-difluoropropane

B. 3-chloro-1-fluoropropane

C. 1-chloro-3,3-difluoropropane

D. 3-chloro-1,1-difluoropropane

8 In which of the following pairs are the substances isomers of each other?

A. 1-pentene and cyclopentane

B. Pentane and 2,3-dimethylbutane

C. Butanoic acid and 1,2-butanediol

D. Dichloromethane and trichloromethane

9 At 100°C, the equilibrium constant for the reaction below is 0.48.

N_2O_4 *(g)* $\rightleftharpoons$ $2NO_2$ *(g)* $K_{eq} = 0.48$

In an experiment it was found that the equilibrium concentration of N_2O_4 *(g)* was 0.20 mol/L. Calculate the concentration of NO_2 *(g)* in this equilibrium mixture, in mol/L.

A. 0.096

B. 0.31

C. 0.24

D. 0.48

10 Which is the INCORRECT statement about the reaction when liquid ethanol burns in air?

A. The enthalpy and entropy changes for the reaction are both negative.

B. The reaction is described as combustion.

C. The reaction does not reach equilibrium and the system is classified as open.

D. The enthalpy change is negative and gases form.

11 The low boiling point of liquid hydrocarbons are often classified as being volatile. This means that:

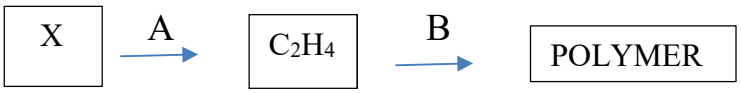
A. they can ignite, even without an ignition source.

B. they can easily change into gas at room temperature.

C. their products of combustion are toxic.

D. they all give out the same amount of energy when combusted.

12 Which of the following most correctly represents X, A,B in the flow chart?



	X	A	B
A.	Glucose	dehydration	addition polymerisation
B.	Ethanol	oxidation	condensation polymerisation
C.	Glucose	addition	condensation polymerisation
D.	Ethanol	dehydration	addition polymerisation

13 The table gives heat of combustion kJ g^{-1} for a number of different fuels.

Fuel	Heat of combustion kJ g^{-1}
Butanol	30.8
Pentanol	36.5
Hexanol	41.2
Petrol (Octane)	47.8

The heat of combustion in kJ mol^{-1} for one of the fuels was calculated as 3218 kJ mol^{-1}. What was the fuel?

A. Hexanol

B. Octane

C. Butanol

D. Pentanol

14 The table below shows pK_{ind}, the pH range, and the colour changes of three indicators.

Indicator	pK_{ind}	pH range	colour at lower pH	colour at higher pH
bromophenol blue	4.0	3.0 - 4.6	yellow	blue
methyl red	5.1	4.2 - 6.3	red	yellow
phenolphthalein	9.3	8.3 - 10.0	colourless	red

At a pH of 4 which option below correctly identifies the colour of the solution:

	Bromophenol blue	**Methyl red**	**Phenolphthalein**
(a)	yellow	red	colourless
(b)	Yellow	yellow	colourless
(c)	Green	orange	colourless
(d)	Green	red	colourless

15 What is the pOH of the solution formed when 20.00 mL of 0.250 mol/L HCl is mixed with 80.00 mL of 0.350 mol/L NaOH solution at 25°C?

A. 0.638

B. 1.638

C. 12.362

D. 13.362

16 In a titration, a 25.00 mL titre of 1.00 mol L^{-1} hydrochloric acid neutralised a 20.00 mL aliquot of sodium hydroxide solution which was in a conical flask. If, in repeating the titration, a student failed to rinse one of the pieces of glassware with the appropriate solution, the titre would be:

A. greater than 25.00 mL, if the final rinsing of the 20.00 mL pipette was with water rather than the base.

B. less than 25.00 mL, if the final rinsing of the burette was with water rather than the acid.

C. equal to 25.00 mL, if water was left in the conical flask after final rinsing.

D. greater than 25.00 mL, if the conical flask was rinsed with the acid prior to the addition of the aliquot.

17 Which of the following will cause the greatest change in pH to a 100 mL sample of 0.1 mol L^{-1} HCl?

A. adding 1.0g of calcium carbonate powder

B. adding 10.0 mL of 0.1 mol L^{-1} NaOH

C. adding 100.0 mL of 0.1 mol L^{-1} HCl

D. diluting the sample to 1000.0 mL

18 The equilibrium constant for the reaction below has an equilibrium constant K_1.

$H_2\,(g) + I_2\,(g) \rightleftharpoons 2HI\,(g) \quad K_1 = 159$ at 500K

At the same conditions of temperature and pressure, what is the equilibrium constant for the reaction:

$HI\,(g) \rightleftharpoons \frac{1}{2}H_2\,(g) + \frac{1}{2}I_2\,(g)$

A. 0.00629

B. 0.0793

C. 12.6

D. 79.5

19 When a sample of NO_2 *(g)* is placed in a container, the following equilibrium is rapidly established:

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

If this equilibrium mixture is a darker colour at high temperatures and at low pressures, which of these statements about the reaction is correct?

A. The reaction is exothermic and NO_2 is darker in colour than N_2O_4.

B. The reaction is exothermic and N_2O_4 is darker in colour than NO_2.

C. The reaction is endothermic and NO_2 is darker in colour than N_2O_4.

D. The reaction is endothermic and N_2O_4 is darker in colour than NO_2.

20 The K_{sp} of $Ca(OH)_2$ at 25°C is 5.02×10^{-6}.

What is the molar solubility of calcium hydroxide at this temperature?

A. 1.71×10^{-2}

B. 1.08×10^{-2}

C. 2.24×10^{-3}

D. 5.06×10^{-4}

Chemistry

Section II – 80 marks
Attempt Questions 21-35
Allow about 2 hours and 25 minutes for this section.

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

Show all relevant working in questions involving calculations.

Extra writing space is provided on
pages 32 to 35. If you use this space, clearly indicate which question you are answering.

Question 21 (6 marks)

A class has been asked to conduct a chemical analysis of a common household substance for acidity or basicity.
Assess **TWO** different methods of how this analysis could be conducted.

(a) **6**

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Question 22 (4 marks)

For the salt silver chloride, $K_{sp} = 1.77 \times 10^{-10}$ at 298 K.

A mixture is formed from 0.25 moles of $AgNO_3$ and 1.0 mole of NaCl in water.

(a) Explain the meaning of K_{sp} for silver chloride. **1**

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(b) Calculate the concentration of silver ions, Ag^+, at equilibrium in this mixture. **3**

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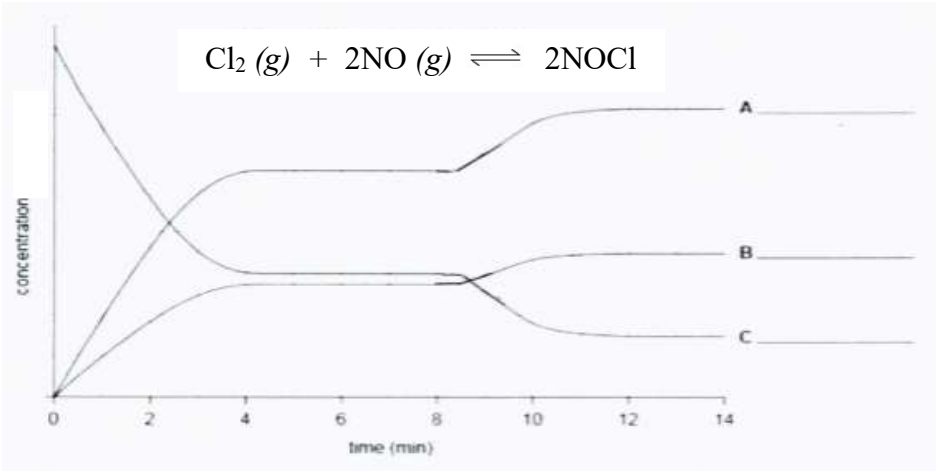
Question 23 (5 marks)

Nitrogen monoxide, chlorine and NOCl form an equilibrium gaseous mixture:

$$Cl_2\ (g)\ +\ 2NO\ (g)\ \rightleftharpoons\ 2NOCl\ (g)$$

The graph below shows the changes in concentration of the three species over time.



(a) On the graph above, identify A, B and C as Cl_2, NO and NOCl. **1**

(b) Describe the change that was made to the reaction conditions at time t = 8.5 min. **1**

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Question 23 continues on the next page

Question 23 (continued)

(c) Will the equilibrium constant at t = 12 min be the same as at t = 6 min? **2**
Explain your response.

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(d) Will the presence of a catalyst impact on the equilibrium in any way? **1**
Explain your response.

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Question 24 (6 marks)

(a) When an aqueous solution of iron (III) nitrate is added to an aqueous sodium phosphate solution, insoluble iron (III) phosphate is formed as one of the products. **1**

Write an equation that represents this reaction.

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(b) If aqueous thiocyanate ions are added to an aqueous solution of iron (III) ions a red colour is produced as an iron (III) thiocyanate complex establishes an equilibrium, releasing heat.

$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftharpoons [FeSCN]^{2+}_{(aq)}$$

Yellow **Red**

i. Explain why this equilibrium mixture appears red at room temperature. **1**

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ii. Explain what would happen if a solution containing phosphate ions was added to the mixture. **2**

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iii. Explain the effect of an increase in temperature on this equilibrium mixture. **2**

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Question 25 (5 marks)

Carbon dioxide gas reacts with carbon tetrafluoride gas to form an equilibrium with carbonyl fluoride gas (COF_2). The equilibrium constant for this reaction is 0.5.

(a) Write the equation that represents this equilibrium reaction. **1**

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(b) Write the equilibrium constant expression for this reaction. **1**

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(c) A sample of 5.00 g of carbon dioxide gas and 29.00 g carbon tetrafluoride gas was injected into a sealed 5.00 L vessel. After a period of time the concentration of carbon tetrafluoride gas was measured again and found to be 4 $g.L^{-1}$. **3**

Determine if this mixture is in equilibrium.

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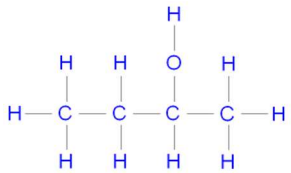
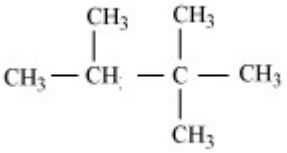
Question 26 (7 marks)

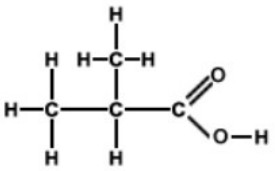
(a) Using IUPAC nomenclature, name the compounds shown below. **3**



Compound 1



Compound 2



Compound 3

Compound 1 ……

Compound 2 ……

Compound 3 ……

(b) Compare the intermolecular forces in the above 3 molecules and predict the order of boiling points (lowest to highest) of these molecules. Explain your prediction. **4**

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Question 27 (5 marks)

A student was asked to distinguish between colourless organic liquids known to be

- butan-1-ol
- butan-2-ol
- 2-methylpropan-2-ol

(a) Explain how the 3 isomers differ in their structures and how these differences allow them to be distinguished using a chemical test. Include a chemical equation in your answer. **3**

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(b) Outline the observations which would be made to allow the 3 liquids to be identified. **2**

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Question 28 (2 marks)

Explain how Aboriginal and Torres Strait Islander Peoples have used the principles of solubility equilibria, when removing toxicity from foods such as cycad fruit. **2**

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Question 29 (7 marks)

Various models of acids and bases have been used over time. Compare the Arrhenius theory, the Bronsted-Lowry theory and one other theory you have explored in your studies and explain the limitations of each model. **7**

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Question 30 (6 marks)

The table shows the acid dissociation constants at 25ºC.

Acid	Formula	K_a
Acetic acid	CH_3COOH	1.8×10^{-5}
Chlorous acid	$HClO_2$	1.1×10^{-2}
Formic acid	$HCOOH$	1.8×10^{-4}
Hydrocyanic acid	HCN	6.2×10^{-10}
Hydrofluoric acid	HF	6.6×10^{-4}
Water	H_2O	1.0×10^{-14}
Lactic acid	$CH_3CHOHCOOH$	1.4×10^{-4}
Nitrous acid	HNO_2	7.2×10^{-4}
Phenol	C_6H_5OH	1.3×10^{-10}

(a) Identify the strongest acid in the table and determine the pK_a value for this acid. **2**

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(b) Calculate the pH of a 0.10 mol L^{-1} solution of nitrous acid. **3**

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(c) Calculate the percentage dissociation of a 0.1 mol L^{-1} solution of nitrous acid. **1**

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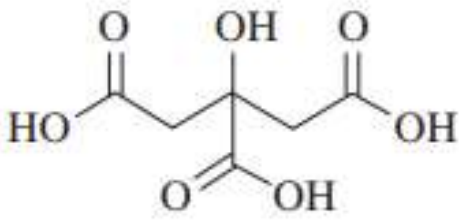
Question 31 (4 marks)

A titration is carried out to determine the citric acid content of 1 L of orange juice.
Citric acid, $C_6H_8O_7$, has the following structural formula and is a triprotic weak acid.



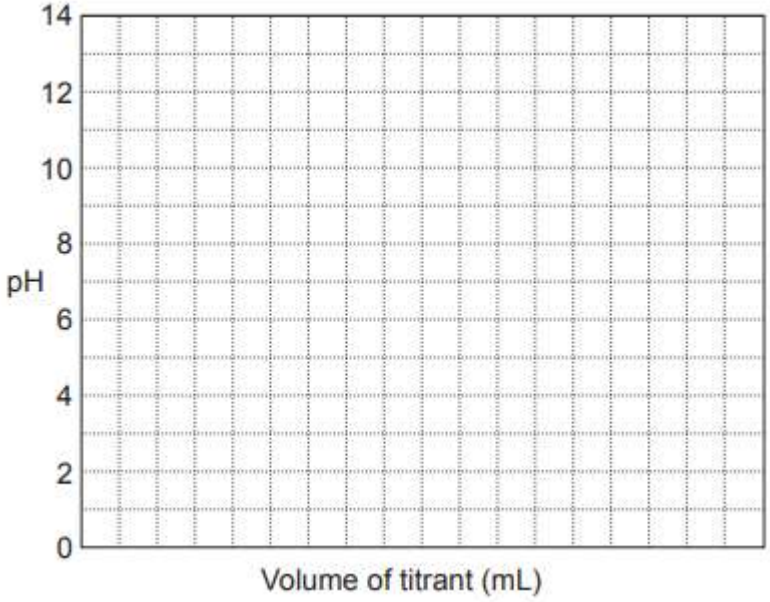
First, a solution of sodium hydroxide was standardised by titration against potassium hydrogen phthalate (a weak acid) and found to have a concentration of exactly 0.0540 mol L^{-1}.

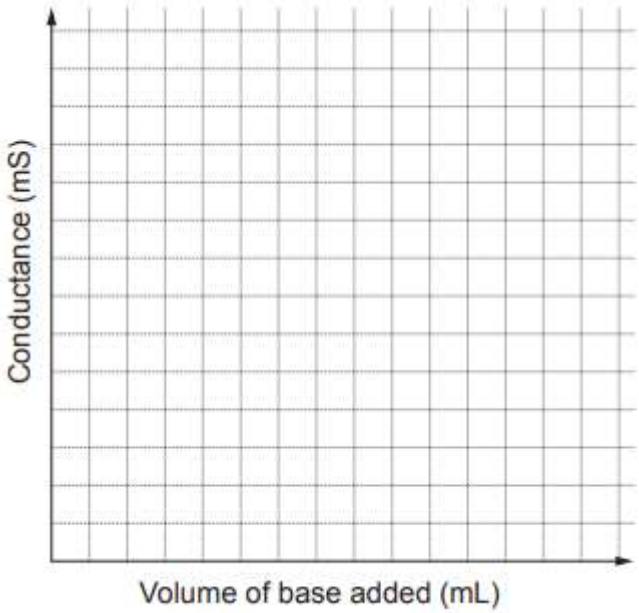
Next, the orange juice was diluted by taking 10 mL of juice and making it up to 50 mL with distilled water. 25 mL samples of the diluted orange juice were placed in clean conical flasks and titrated against the standardised sodium hydroxide. The average amount of sodium hydroxide needed to reach equivalence was 17.3 mL.

Question 31 continues on the next page

Question 31 (continued)

Complete the graphs to show the change in pH and the change in conductivity during the titration. Indicate the equivalence point on each graph. **4**





Question 32 (4 marks)

To determine the percentage by mass of calcium carbonate ($CaCO_3$) in an antacid tablet which had a mass of 0.250 g, the following procedure was used:

- The tablet was crushed and then placed in a beaker.
- A pipette was used to add 25.0 mL of 0.120 mol L^{-1} hydrochloric acid to the crushed tablet in the beaker.
- Once the reaction between the calcium carbonate and hydrochloric acid had stopped, phenolphthalein indicator was added to the reaction mixture.
- A burette was then used to add 0.0560 mol L^{-1} sodium hydroxide to the beaker to neutralise the excess hydrochloric acid.
- The phenolphthalein changed from colourless to pink after 27.4 mL of the sodium hydroxide solution had been added.

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

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(b) Determine the percentage by mass of calcium carbonate in the tablet. Show all working and reasoning. **3**

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Question 33 (4 marks)

A green solution was made containing a weak acid, *HA* (which is a yellow molecule) and its conjugate base, A^- (which is blue).

(a) Write an equation for the reaction which occurs when a strong base such as sodium hydroxide is added to this solution. **1**

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(b) Write an equation for the reaction which occurs when a strong acid such as hydrochloric acid is added to this solution. **1**

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(c) Use your equations from part (a) and (b) to explain why this solution can act as an indicator. **2**

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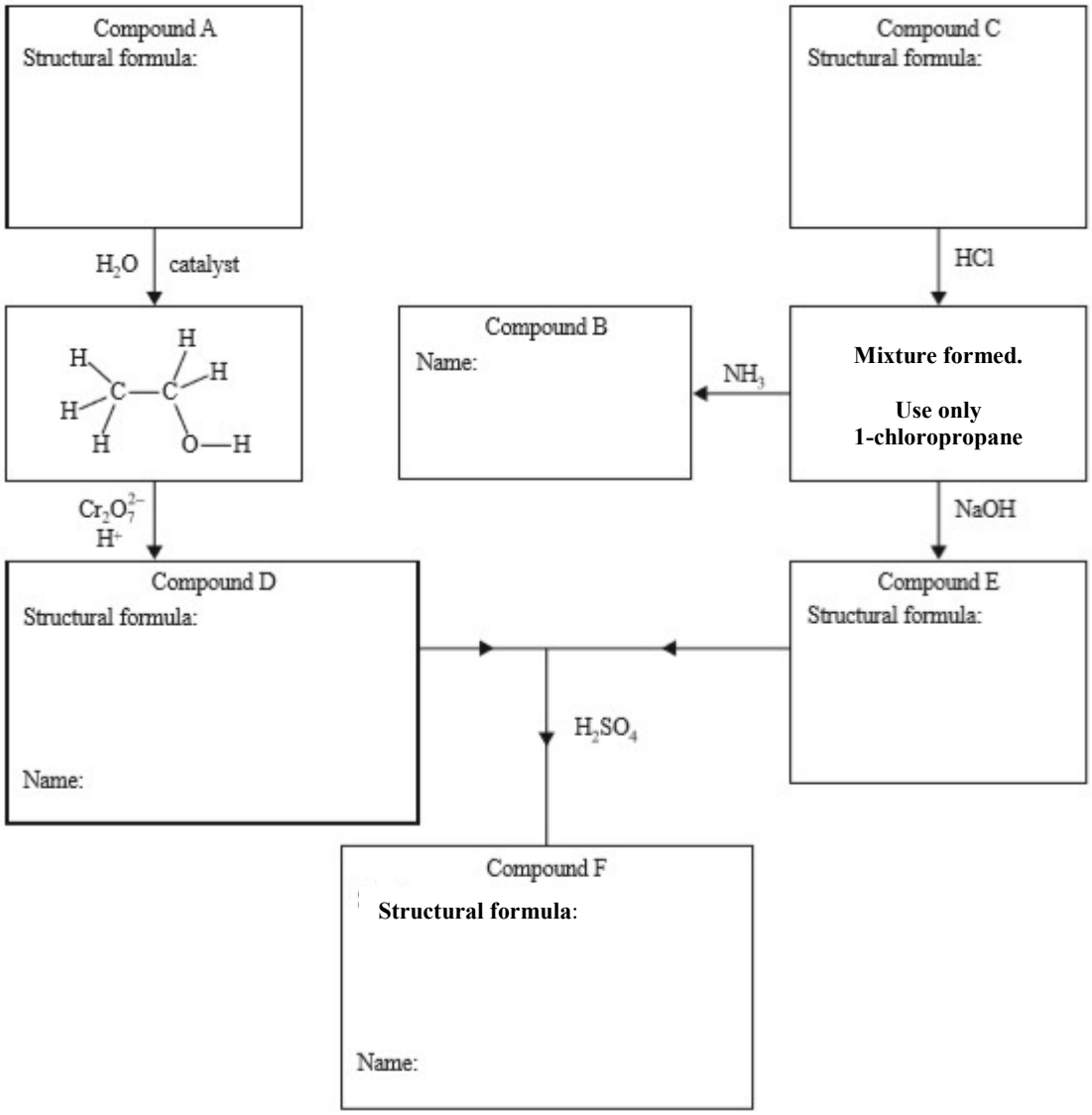
Question 34 (10 marks)

(a) Complete the diagram below by inserting: **8**

- structural formulae for compounds A, C, D, E and F
- the IUPAC names for compounds B, D and F

Compounds B and F may be synthesised as follows.



(b) Identify the types of reactions which occur when: **2**

- Compound C is converted to 1-chloropropane ……..
- 1-chloropropane is converted to Compound E ……..

Question 35 (5 marks)

(a) In the space below, draw the structural formula for each reactant required to produce pentyl acetate in the laboratory. Name each reactant. **2**

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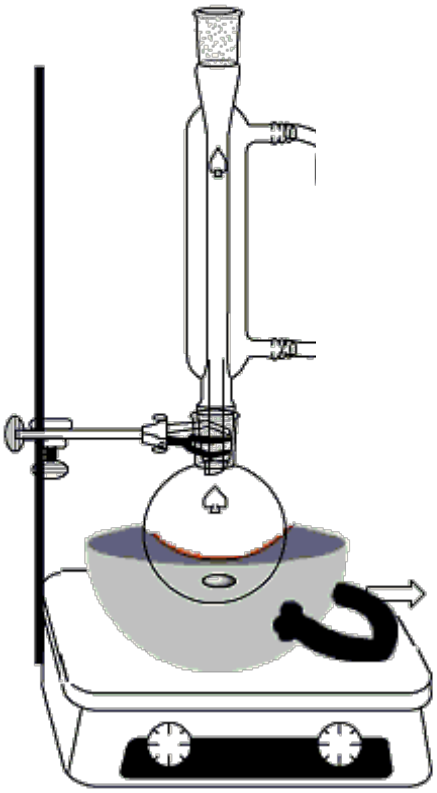
(b) The image below shows the equipment used for this reaction. **3**



Explain reasons for using the apparatus above in this technique.

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Space to answer Question 35 continues on the next page

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End of Paper

Section II - Extra writing space

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Section II - Extra writing space

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Section II - Extra writing space

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Section II - Extra writing space

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Student Name:……

CHEMISTRY – MULTIPLE-CHOICE ANSWER SHEET

ATTEMPT ALL QUESTIONS

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

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FORMULAE SHEET

$$n = \frac{m}{MM} \qquad c = \frac{n}{V} \qquad PV = nRT$$

$$q = mc\Delta T \qquad \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \qquad \text{pH} = -\log_{10}[\text{H}^+]$$

$$pK_a = -\log_{10}[K_a] \qquad A = \varepsilon lc = \log_{10}\frac{I_o}{I}$$

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Gas constant ..... 8.314 J mol^{-1} K^{-1}

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

DATA SHEET

Solubility constants at 25°C

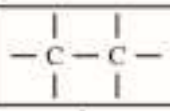
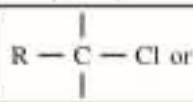
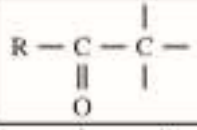
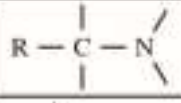
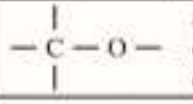
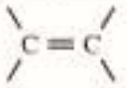
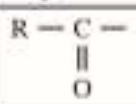
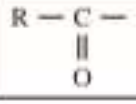
Compound	K_{sp}	*Compound*	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}	Lead(II) hydroxide	1.43×10^{-15}
Calcium hydroxide	5.02×10^{-6}	Lead(II) phosphate	8.0×10^{-43}
Calcium phosphate	2.07×10^{-29}	Lead(II) sulfate	2.53×10^{-8}
Calcium sulfate	4.93×10^{-5}	Magnesium carbonate	6.82×10^{-6}
Copper(II) carbonate	1.4×10^{-10}	Magnesium hydroxide	5.61×10^{-12}
Copper(II) hydroxide	2.2×10^{-20}	Magnesium phosphate	1.04×10^{-24}
Copper(II) phosphate	1.40×10^{-37}	Silver bromide	5.35×10^{-13}
Iron(II) carbonate	3.13×10^{-11}	Silver chloride	1.77×10^{-10}
Iron(II) hydroxide	4.87×10^{-17}	Silver carbonate	8.46×10^{-12}
Iron(III) hydroxide	2.79×10^{-39}	Silver hydroxide	2.0×10^{-8}
Iron(III) phosphate	9.91×10^{-16}	Silver iodide	8.52×10^{-17}
		Silver phosphate	8.89×10^{-17}
		Silver sulfate	1.20×10^{-5}

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

Infrared absorption data

Bond	Wavenumber/cm^{-1}
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

^{13}C NMR chemical shift data

Type of carbon		δ/ppm
		5–40
		10–70
		20–50
		25–60
	alcohols, ethers or esters	50–90
		90–150
		110–125
		110–160
	esters or acids	160–185
	aldehydes or ketones	190–220

UV absorption

(This is not a definitive list and is approximate.)

Chromophore	λ_{max} (nm)
C—H	122
C—C	135
C=C	162

Chromophore	λ_{max} (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	−2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	−2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	−2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	−2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	−2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	−1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	−1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	−0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	−0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	−0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	−0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	−0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	−0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

PERIODIC TABLE OF THE ELEMENTS

KEY	
Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Uut Ununtrium	114 Fl Flerovium	115 Uup Ununpentium	116 Lv Livermorium	117 Uus Ununseptium	118 Uuo Ununoctium

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (January 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

ANSWERS

MARKING CRITERIA

ANNOTATED

2019 Higher School Certificate
Trial Examination

Mapping Grid

Section I

Question	Answer
1	D
2	A
3	C
4	B
5	C
6	D
7	D
8	A
9	B
10	A
11	B
12	C
13	D
14	B
15	A
16	C
17	A
18	B
19	A
20	B

Section II – 80 marks

Question 21 (7 marks)
21 (6 marks)
Outcomes Assessed: CH12–3, CH12–13
Targeted Performance Bands: 2-6

Criteria	Marks
• Describes TWO methods in detail-equipment and reagents AND • Outlines advantages AND disadvantages of each method AND • Provides overall judgement about the methods • Response is well written and succinct	6
• As above but only gives advantage and disadvantage of each method or response is not well written	5
• As above but methods are not described in enough detail- lacking chemicals and or equipment • Judgement is not explicit	4
• Outlines 2 methods, provides advantages or disadvantages of both methods or provides advantages and disadvantages of only 1 method	3
• Provides very basic details about one or 2 methods- no advantages or disadvantages	2
• Some correct details provided	1

Sample answer

The sample must be dissolved if a solid- it must be dissolved in distilled/deionised water. One method is to use indicators, so the sample should also form a transparent colourless solution when using indicators.
A couple of drops of the test substance should be placed on a well plate with 1-2 drops of universal indicator the colour change should be recorded and compared to the indicator's colour chart to identify the pH of the substance according to the colour chart.
This method is quick,easy to use and does ot use much of the reagents, however it is destructive and it is reliant upon the person reading the colour accurately and comparing to chart accurately.

A pH probe can also be used which is non-destructive and very quick. The probe needs to be carefully calibrated and it needs to be used carefully, rinsed carefully and stored in appropriate buffer. It provides a digital reading of the H often to 2 decimal places with a small error.
Overall both methods allow the substance to be determined as acidic or basic depending on their pH the method would be chosen depending if the sample is abundant and if it needs decimal place results.
Students can make any judgement as long as their response supports their judgement

Question 22 (4 marks)
22 (a) (1 mark)
Outcomes Assessed: CH12–12
Targeted Performance Bands: 5

Criteria	Marks
• Correctly explains the meaning of K_{sp} by relating it to an equilibrium of ions in a saturated solution.	1

Sample answer
K_{sp} is the solubility product constant. It is the equilibrium constant for an equilibrium between a solid and its respective ions in a saturated solution. Its value indicates the degree to which a compound dissociates in water.

22 (b) (3 marks)
Outcomes Assessed: CH12–4, CH12–12
Targeted Performance Bands: 5-6

Criteria	Marks
• Correctly calculates the concentration of silver ions at equilibrium in the solution	3
• Calculates a concentration of silver ions by referring to an excess of chloride ions and uses the correct K_{sp} expression	2
• Calculates a concentration of silver ions by referring to an excess of chloride ions OR uses the correct K_{sp} expression	1

Sample answer

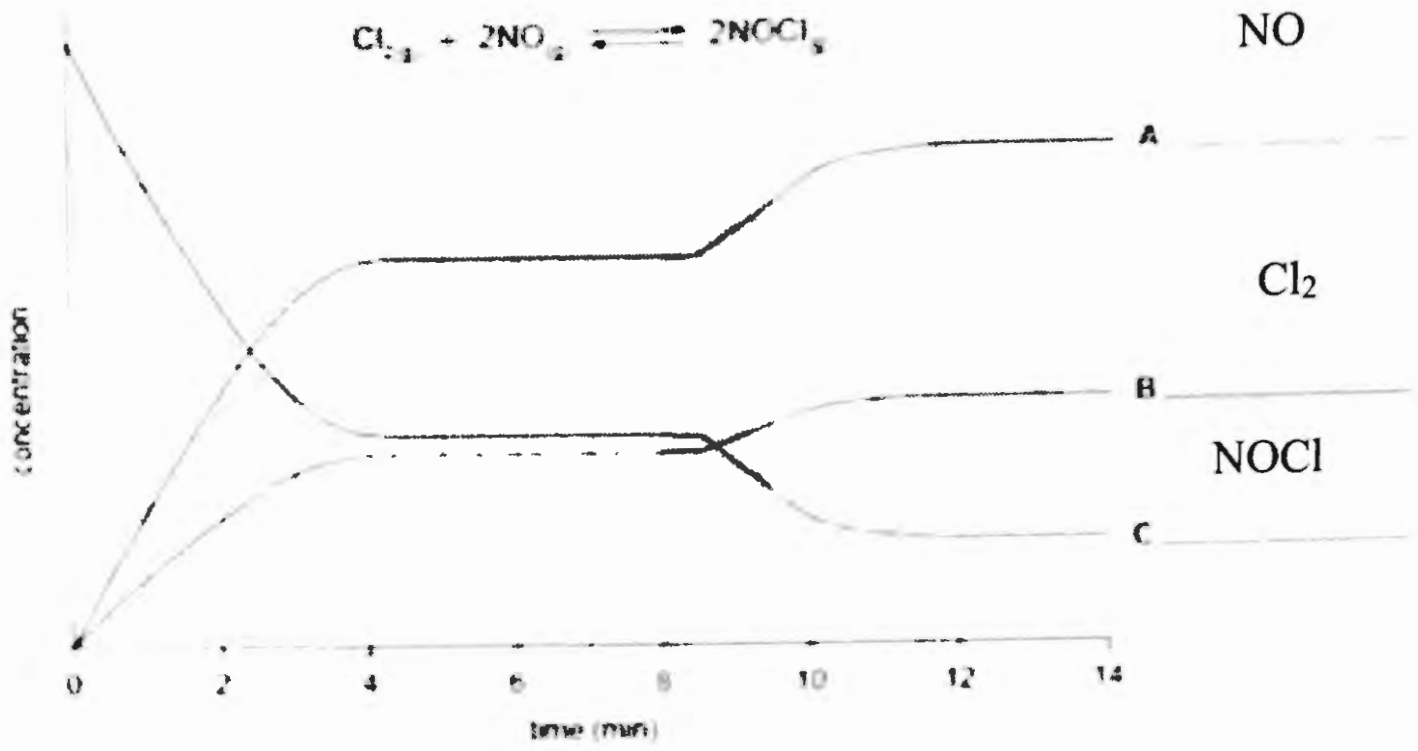
$AgNO_3$ is the limiting reagent, so moles AgCl formed = 0.25
$\therefore$ moles Cl^- remaining = 0.75
$K_{sp} = [Ag^+] \times [Cl^-] = 1.77 \times 10^{-10}$

$$[Ag^+] = \frac{1.77 \times 10^{-10}}{[Cl^-]} = \frac{1.77 \times 10^{-10}}{0.75} = 2.36 \times 10^{-10} \text{ mol L}^{-1}$$

Question 23 (5 marks)
23 (a) (1 mark)
Outcomes Assessed: CH12–5, CH12–12
Targeted Performance Bands: 3-4

Criteria	Mark
• Correctly identifies A, B and C	1

Sample answer



23 (b) (1 mark)
Outcomes Assessed: CH12–7, CH12–12
Targeted Performance Bands: 3-5

Criteria	Mark
• Describes that a temperature change has occurred (which could be an increase or decrease in temperature)	1

Sample answer
A change in temperature has occurred.
As no data has been given as to whether the forward reaction is exothermic or endothermic, it is not possible to state whether the temperature has increased or decreased. The change in temperature has caused a shift in the equilibrium towards the left (as the equation is written in the question paper) – producing higher concentrations of chlorine and nitrogen monoxide and a lower concentration of NOCl. If the forward reaction is exothermic, then an increase in temperature has occurred. Conversely, if the forward reaction (as written in the question paper) is endothermic, a decrease in temperature has occurred. Le Chatelier's Principle predicts that, if an equilibrium is disturbed, an increase in temperature favours the endothermic reaction.

23 (c) (2 marks)
Outcomes Assessed: CH12–6, CH12–7, CH12–12
Targeted Performance Bands: 2-3

Criteria	Marks
• Identifies that the equilibrium constants at t = 6 min and at t = 12 min differ because the temperature has changed	2
• Identifies that the equilibrium constants are different	1

Sample answer
Equilibrium constants depend on temperature.

Since the temperature changed at t = 8 min but did not change again, the equilibrium constant at t = 6 min will differ from the equilibrium constant t = 12 min.

23 (d) (1 mark)
Outcomes Assessed: CH12–7, CH12–12
Targeted Performance Bands: 3-4

Criteria	Mark
• Correct answer in terms of rates and yield	1

Sample answer
A catalyst will increase the rate both of the backward and forward reactions equally and will hence decrease the time taken for a new equilibrium to be achieved after an imposed change. However, it will not alter the concentrations of the species at equilibrium. Hence the presence of a catalyst will not alter the equilibrium constants.

Question 24 (5 marks)

24 (a) (1 mark)

Outcomes Assessed: CH12–4, CH12–15

Targeted Performance Bands: 4

Criteria	Mark
• Equation has correct formulae, is correctly balanced and has correct states.	1

Sample answer

$Fe(NO_3)_{3\,(aq)} + Na_3PO_{4\,(aq)} \rightarrow Fe\,PO_{4\,(s)} + 3NaNO_{3\,(aq)}$

24 (b)(i) (2 marks)

Outcomes Assessed: CH12–4, CH12–6, CH12–12

Targeted Performance Bands: 4-5

Criteria	Marks
• Clear and accurate explanation of why the equilibrium mixture is reddish at room temperature with reference to Le Chatelier's Principle	2
• Explanation of why the equilibrium mixture is reddish at room temperature with some detail missing.	1

Sample answer

At equilibrium this reaction is reddish because even though all three ions are present in the solution, the iron (III) thiocyanate ions have the highest concentration. The equilibrium lies to the right at this temperature.

24 (b)(ii) (2 marks)

Outcomes Assessed: CH12–4, CH12–6, CH12–12

Targeted Performance Bands: 4-6

Criteria	Marks
• Clearly and accurately explains that the addition of phosphate ions would precipitate a solid and cause a shift in the equilibrium.	2
• Explains that the addition of phosphate ions would precipitate a solid and cause a shift in the equilibrium with some detail missing	1

Sample answer

If phosphate ions were added to this mixture they would react with the Fe^{3+} ions and form a solid. Since these ions are now removed from the solution the equilibrium would shift to the left and the mixture would become a lighter red or yellowish colour.

Question 25 (5 marks)

25 (a) (1 mark)

Outcomes Assessed: CH12–4, CH12–12

Targeted Performance Bands: 2-3

Criteria	Mark
• Equation is an equilibrium, has correct formulae and is correctly balanced.	1

Sample answer

$CO_{2\,(g)} + CF_{4\,(g)} \rightleftharpoons 2COF_{2\,(g)}$

25 (b) (1 mark)

Outcomes Assessed: CH12–5, CH12–7, CH12–12

Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly writes the equilibrium constant expression for this reaction.	1

Sample answer

$$K = \frac{[COF_2]^2}{[CO_2] \times [CF_4]}$$

25 (c) (3 marks)

Outcomes Assessed: CH12-4, CH12-5, CH12–6, CH12–12

Targeted Performance Bands: 5-6

Criteria	Marks
• Correctly determines that the mixture is not in equilibrium by correctly calculating concentrations and using an ICE table or equivalent.	3
• Determines that the mixture is not in equilibrium by correctly calculating concentrations OR using an ICE table or equivalent.	2
• Correctly calculating concentrations or uses an ICE table or a correct mathematical expression for K.	1

Sample answer

Initial $[CO_2] = 1.0 \text{ g L}^{-1} = 1 / (12.01 + 32) \text{ mol L}^{-1}$
$= 0.0227221086 \text{ mol L}^{-1}$

Initial $[CF_4] = 5.8 \text{ g L}^{-1} = 5.8 / [12.01 + (4 \times 19)] \text{ mol L}^{-1}$
$= 0.06590160209 \text{ mol L}^{-1}$

Final $[CF_4] = 4 \text{ g L}^{-1} = 4 / [12.01 + (4 \times 19)] \text{ mol L}^{-1}$
$= 0.04544938075 \text{ mol L}^{-1}$

	$[CO_2]$	$[CF_4]$	$[COF_2]$
Initial	**0.023**	**0.066**	0.00
Change	−0.021	−0.021	+0.042
Final	0.002	**0.045**	0.042

$$K_{eq} = \frac{[COF_2]^2}{[CO_2] \times [CF_4]} = \frac{(0.042)^2}{0.002 \times 0.045} = 19.6$$

K_{eq} is greater than 0.5. The mixture is not in equilibrium.

Question 26 (7 marks)

26 (a) (3 marks)

Outcomes Assessed: CH12–7, CH12–14

Targeted Performance Bands: 3-5

Criteria	Marks
• Names THREE compounds correctly	3
• Names TWO compounds correctly	2
• Names ONE compound correctly	1

Sample answer

Compound 1 = butan-2-ol
Compound 2 = 2,2,3-trimethylbutane
Compound 3 = 2-methylpropanoic acid

23 (b) (4 marks)
Outcomes Assessed: CH12–7, CH12–14
Targeted Performance Bands: 3-5

Criteria	Marks
• Predicts the correct order of boiling points • Explains thoroughly the impact of the different intermolecular forces • Identifies that Compound 1 has hydrogen bonding as the strongest intermolecular force • Identifies that Compound 2 has dispersion (temporary dipole-dipole forces) only • Identifies that Compound 3 has hydrogen bonding (2 hydrogen bonds form between adjacent molecules)	4
• Predicts the correct order of boiling points • Explains thoroughly the impact of the different intermolecular forces • Identifies the intermolecular forces in 2 of the 3 compounds	3
• TWO of: • Predicts the correct order of boiling points • Explains thoroughly the impact of the different intermolecular forces • Identifies the intermolecular forces in 2 of the 3 compounds	2
• ONE of: • Predicts the correct order of boiling points • Explains thoroughly the impact of the different intermolecular forces • Identifies the intermolecular forces in 1 of the 3 compounds	1

Sample answer
The order of increasing boiling point is Compound 2, Compound 1, Compound 3.

The stronger the intermolecular forces, the higher the boiling point, as greater energy is needed to separate the liquid molecules to form a gas.

Compound 2 is non-polar and has only weak intermolecular forces (dispersion or temporary dipole-dipole forces) caused by the electrical interaction of molecules as they collide (protons from 1 molecule being attracted to electrons from the other as the molecules are temporarily distorted on collision).

Compound 1 is polar and would experience hydrogen bonding forces, as well as weaker temporary and permanent dipolar forces) as molecules interact. These are strong intermolecular forces where the electronegativity of the oxygen results in a very polar bond with hydrogen in the O–H group. This hydrogen is attracted to the oxygen of a neighbouring alcohol molecule. The geometry of the molecule only allows 1 H-bond per pair of molecules at any instant.

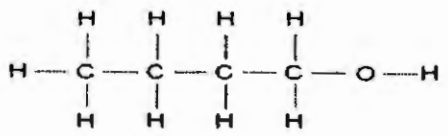
Compound 3 is an acid and has the very polar – COOH functional group. The hydrogen atom of the –COOH can form a hydrogen bond with an oxygen of the neighbouring acid molecule. The planar nature of this –COOH group allows 2 H-bonds per pair of molecules.
Hence the intermolecular forces and thus boiling points are highest in Compound 3 and lowest in Compound 2.

Question 27 (5 marks)
27 (a) (3 marks)
Outcomes Assessed: CH12–7, CH12–15
Targeted Performance Bands: 2-5

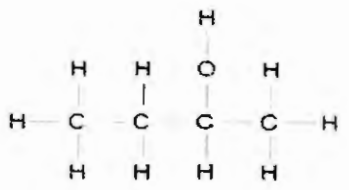
Criteria	Marks
• Identifies the isomers as primary, secondary or tertiary alcohols and hence explains the difference in structures of the 3 isomers • Outlines the method of distinguishing between the 3 alcohols, which depends on the difference in structures	2
• ONE of the above	1

Sample answer
The 3 chemicals listed are isomers (all have the same molecular formula) and are all alcohols. They differ, in that butan-1-ol is a primary alcohol, butan-2-ol is a secondary alcohol and 2-methylpropan-2-ol is a tertiary alcohol.

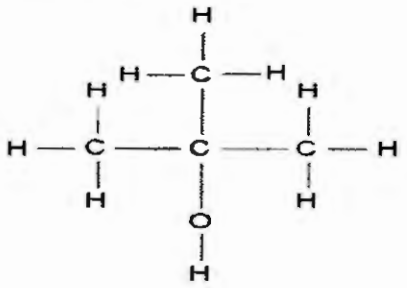
Primary alcohol: the –OH group is attached to a terminal carbon. The –OH group is attached to a carbon which is attached to only 1 other carbon; e.g. butan-1-ol.



Secondary alcohol: the –OH group is attached to a carbon which is attached to 2 other carbons; e.g. butan-2-ol.



Tertiary alcohol: the –OH group is attached to a carbon which is attached to 3 other carbons; e.g. 2-methylpropan-2-ol.



The 3 types of alcohols are distinguished between by reaction of a sample of each alcohol with acidified potassium dichromate solution, followed by testing of any products to distinguish between the primary and secondary alcohols. The 3 alcohols react differently; primary alcohols produce carboxylic acids, secondary alcohols produce alkanones and tertiary alcohols do not react.

27 (b) (2 marks)
Outcomes Assessed: CH12–7, CH12–15
Targeted Performance Bands: 2-4

Criteria	Marks
• Outlines the observations (being colour changes from orange to green) for the oxidation reactions of primary and secondary alcohols AND outlines that no colour change is observed for the tertiary alcohol AND outlines that the product of oxidation of a primary alcohol is acidic and hence can be distinguished from the product of oxidation of a secondary alcohol	2
• ONE of the above	1

Sample answer
Primary alcohols react with excess acidified potassium dichromate solution to form a carboxylic acid. The oxidising agent is converted into green chromate ions. The presence of the acid in solution could be tested by **separating the product** and testing a sample of the product with sodium carbonate solution; carbon dioxide bubbles would be produced. In this reaction, butan-1-ol is converted to butanal and then butanoic acid.

Secondary alcohols react with acidified potassium dichromate solution but form ketones/alkanones, not acids. Here butan-2-ol reacts to form propanone (acetone). There is a colour change but no acid is formed.

Tertiary alcohols are not oxidised by acidified potassium dichromate solution, so no colour change occurs when the reagents are mixed.

Question 28 (2 marks)
28 (2 marks)
Outcomes Assessed: CH12–7, CH12–12
Targeted Performance Bands: 2-4

Criteria	Marks
• Explains thoroughly how Aboriginal and Torres Strait Islander Peoples use the principles of solubility equilibria to remove toxins from foods	2
• Explains some aspects of removal of toxicity by leaching	1

Sample answer
Aboriginal and Torres Strait Islander Peoples remove soluble toxic substances from foods by leaching.

For example, cycad seeds are used in making breads, but these breads are poisonous if the seeds are not crushed and leaching used to remove the poisons.

The paste formed is left in water until the solubility of the poison in water is reached. This is achieved when the solubility equilibrium between the solid poison and the solution of poison has been achieved. The solution has then become saturated with the toxin. The equilibrium is then destroyed by removing the saturated solution containing the toxin, adding new pure water and waiting until equilibrium is again reached. The saturated solution is removed, fresh water added and the process repeated. Each step drives the equilibrium to the right and reduces the amount of toxin remaining in the seed.

The seed is then roasted to remove any residual toxin, before being used in cooking.

Question 29 (7 marks)

Criteria	Marks
• Explains Arrhenius AND Bronsted Lowry AND one other theory with correct examples provided • Distingushes between the theories/makes clear how they advanced our understanding • Answer is concise and logical	7
• As above but answer is not set out in a logical manner9jumps from one model to another in no order)	6
• Explains Arrhenius AND Bronsted Lowry AND one other theory with correct examples provided of at least 2 theories • Response acknowledges our understanding has changed with each model but does not make clear how this has occurred.	5
• Explains Arrhenius AND Bronsted Lowry AND one other theory with correct examples provided of at least 2 theories	4
• Identifies and defines in very brief detail 3 theories succession of understanding not demonstrated	3
• Identifies and defines in very brief detail 2 theories succession of understanding not demonstrated	2
• Some correct information provided	1

Sample answer

The Brönsted-Lowry theory classifies an acid as a proton donor and a base as a proton acceptor. For example the proton is lost from the acid HCl *(g)* and gained by the base ammonia. The Brönsted-Lowry theory classification is irrespective of the state of the reactants, so the reaction can occur in the gaseous state.
Provide a correct equation

Arrhenius described acid-base reactions as reactions which took place only in aqueous solution. An acid produced H^+ (now H_3O^+) as the only positive ion in solution. A base was an oxide or hydroxide that produced hydroxide ions in aqueous solution. Ammonia would not be classified as a base with this theory for example.
Provide correct examples eg HCl, NaOH

Another theory described correctly with examples/equations

Our understanding has changed with each model as new information is gained our classification of what an acid and base is has changed/improved.

Question 30 (6 marks)
(a) (2 marks)
Outcomes Assessed: CH12–5, CH12–13
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies chlorous acid as the strongest acid AND determines the pK_a value for the identified acid	2
• Identifies chlorous acid as the strongest acid OR determines the pK_a value for the identified acid	1

Not doing sig fig for pH

Sample answer
Chlorous acid, $HClO_2$
$pK_a = -\log(K_a) = -\log(1.1 \times 10^{-2}) = 1.96$ (~~2 s.f.~~) (same rule for s.f. in pK_a calculations as in pH)

27 (b) (3 marks)
Outcomes Assessed: CH12–5, CH–6, CH12–13
Targeted Performance Bands: 3-6

Criteria	Marks
• ~~Calculates the pH to 2 s.f.~~ • Correctly determines the $[H_3O^+]$ • Shows correct working and reasoning (-x can ignore so small)	3
• Correctly determines the $[H_3O^+]$ • Shows correct working ~~and reasoning~~	2
• Shows some correct working and reasoning	1

Sample answer
$HNO_2\ (aq) + H_2O\ (l) \rightleftharpoons NO_2^-\ (aq) + H_3O^+\ (aq)$

$$K_a\ HNO_2 = \frac{[NO_2^-]\,[H_3O^+]}{[HNO_2]} = 7.2 \times 10^{-4}$$

Let x moles of HNO_2 ionise, forming x moles of H_3O^+

$$K_a\ HNO_2 = \frac{[x]\,[x]}{[0.10 - x]} = 7.2 \times 10^{-4}$$

Since x will be small by comparison with 0.10
Hence $[x]^2 = 7.2 \times 10^{-4} \times 0.10 = 7.2 \times 10^{-5}$
$[H_3O^+] = \sqrt{(7.2 \times 10^{-5})} = 8.5 \times 10^{-3}$ mol/L
Hence pH $= -\log_{10}(8.5 \times 10^{-3}) = 2.07$ (~~2 s.f.~~)

Note for teachers: In mathematical terms, the number to the left of the decimal point in a logarithm is called the characteristic and the number to the right of the decimal point is called the mantissa. The mantissa has as many significant figures as the number from which the logarithm was determined. Hence $[H_3O^+] = 8.5 \times 10^{-4}$, pH = 2.07.

30 (c) (1 mark)
Outcomes Assessed: CH12–5, CH–6, CH12–13
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly calculates the percentage dissociation of nitrous acid	1

Sample answer

$[H_3O^+] = 8.5 \times 10^{-3}$ mol/L
$[HNO_2] = 0.10$ mol/L

$$\% \text{ dissociation} = \frac{8.5 \times 10^{-3}}{0.10} \times 100$$

% dissociation = 8.5% (2sf) should be 1 sig fig.

Sample Q's

Question 31 (4 marks)
Outcomes Assessed: CH12–4, CH–6, CH12–13
Targeted Performance Bands: 2-5

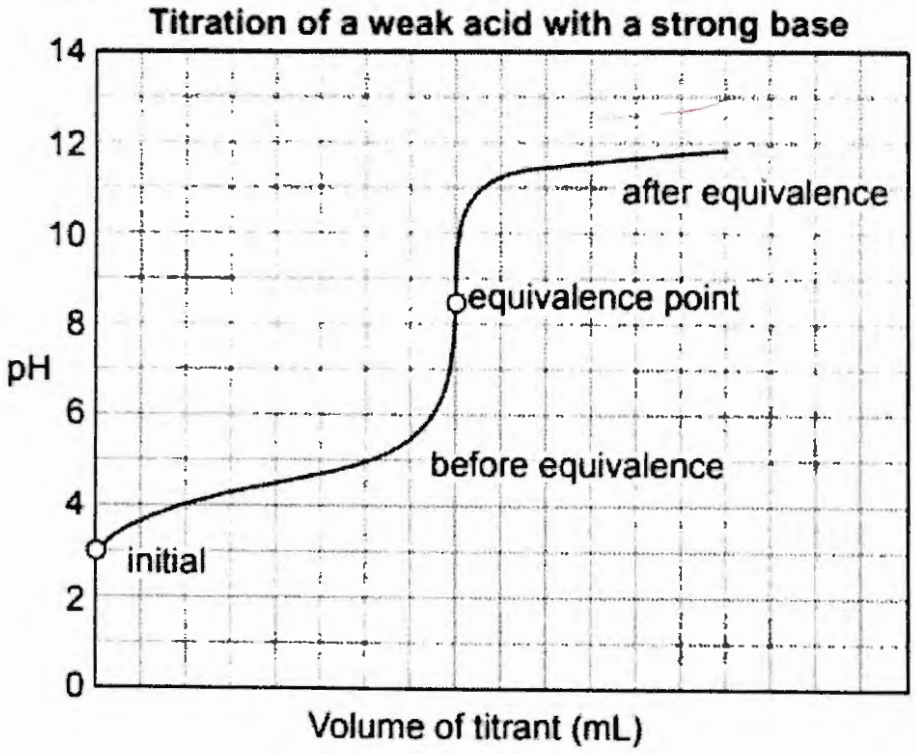
weak acid + strong base
pH begins/ends approp.

Marking guidelines (b):

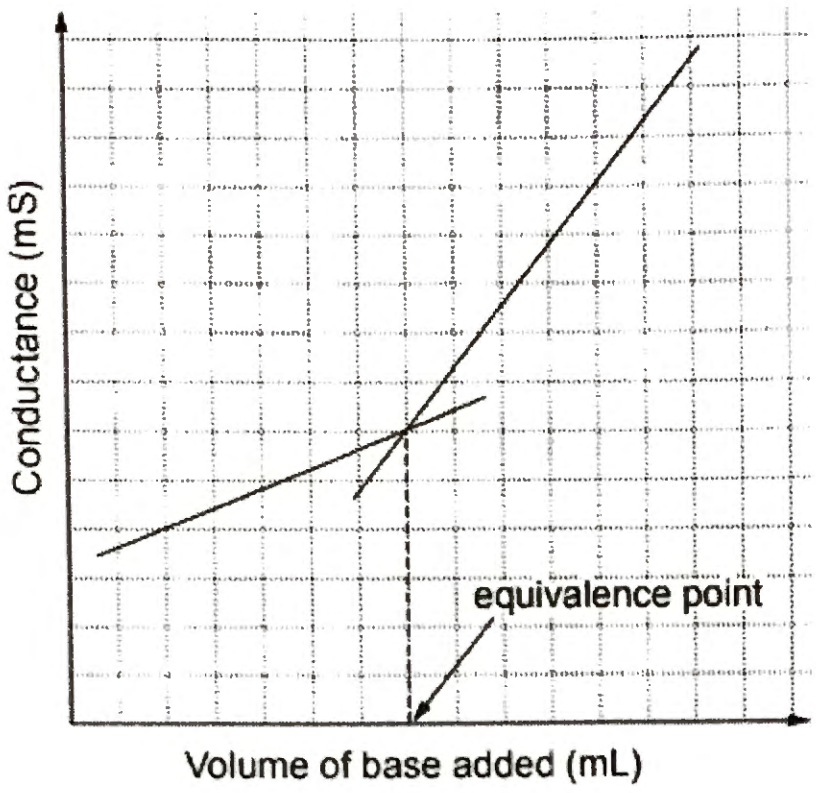
Criteria	Marks
• Provides TWO correct graphs with equivalence point indicated for each	4
• Provides TWO substantially correct graphs with an equivalence point indicated OR • Provides TWO correct graphs	3
• Provides a substantially correct graph with an equivalence point indicated OR • Provides TWO substantially correct graphs	2
• Provides some relevant information	1

Eg. basically correct titration curve in reverse. But not for conductance as labelled vol. of base

Sample answer



- initial + final pH must be appropriate
- equiv. should be suitable position
- Shape reasonable of curve.
- equiv. labelled/indicated.



- beginning low as weak acid
- after equiv. higher & go up signif.

- labelled equiv.

this OK too, as some textbooks use this, and can be complicated depending on subst + Conc.

Question 32 (7 marks)

28 (a) (1 mark)

Outcomes Assessed: CH12–7, CH12–13

Targeted Performance Bands: 2-3

Criteria	Mark
• Writes a correct balanced equation	1

Sample answer

$CaCO_3\ (s) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + CO_2\ (g) + H_2O\ (l)$

28 (b) (3 marks)

Outcomes Assessed: CH12–5, CH–6, CH12–13

Targeted Performance Bands: 2-5

Criteria	Marks
• Calculates correctly the percentage by mass of $CaCO_3$ in the tablet	3
• Determines the moles of HCl in excess	2
• Determines the moles of HCl added to the flask	1

Sample answer

There were 3 steps in the process:

- A tablet was crushed and placed in a beaker
- 25.0 mL of 0.120 M hydrochloric acid was pipetted into the beaker
- The excess HCl was titrated with NaOH to determine the no. of moles of HCl in excess and hence the no. of moles of $CaCO_3$

Moles HCl added initially to react and dissolve $CaCO_3$ = cV = 0.120 x 0.025 = 0.00300 mol

Moles NaOH required for titration excess HCl = 0.0274 x 0.0560 = 0.00153 mol or 0.00153 44

Hence moles of excess HCl = 0.00153 (as NaOH and HCl react in 1:1 ratio)

Moles of HCl which had reacted with tablet = 0.00300 – 0.00153 = 0.00147 mol 0.001465

Moles $CaCO_3$ = ½ moles HCl (from balanced equation)

Hence moles $CaCO_3$ in tablet = 0.000735 mol 7.325 x 10⁻⁴

Mass of $CaCO_3$ in tablet = n x M = 0.000735 x 100.1 = 0.0736 g (3 s.f.)

% $CaCO_3$ in tablet = 0.0736/0.250 x 100 = 29.4% 29.3

(was fairly kind on labels, but do not ignore on HSC!)
(keep sig fig eg 0.00300 mol not 0.003 mol
Initial HCl
(keep working clear, show detail of your process in case you make an error somewhere)

Question 33 (4 marks)

33 (a) (1 mark)

Outcomes Assessed: CH12–5, CH12–13

Targeted Performance Bands: 3

Criteria	Mark
• Correct equation	1

Sample answer

$HA_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)} + A^-_{(aq)}$ OR $HA_{(aq)} + NaOH_{(aq)} \rightarrow NaA_{(aq)} + H_2O_{(l)}$

33 (b) (1 mark)

Outcomes Assessed: CH12–5, CH12–13

Targeted Performance Bands: 3

Criteria	Mark
• Correct equation	1

Sample answer

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

OR $H^+_{(aq)} + A^-_{(aq)} \rightarrow HA_{(aq)}$

OR $HCl_{(aq)} + A^-_{(aq)} \rightarrow HA_{(aq)} + Cl^-_{(aq)}$ (NOT BEST ANSWER)

33 (c) (3 marks)

Outcomes Assessed: CH12–5, CH12–13

Targeted Performance Bands: 3-5

Marking guidelines	Marks
• **Explains why the solution can act as an indicator, as the colour changes with changes in pH / changes in concentration of H3O+** • **AND** • **Refers to the reactions in parts (a) and (b)**	**2**
• **Explains why the solution can act as an indicator, as the colour changes with changes in pH / changes in concentration of H3O+**	**1**

Sample answer

The solution is a green equilibrium mixture of HA (yellow) and A- (blue).

The equilibrium in the solution can be represented:

$HA\ (aq) + H_2O\ (l) \rightleftharpoons A^-\ (aq) + H_3O^+\ (aq)$

yellow blue

When a strong base is added, the reaction in (a) occurs and the indicator solution turns blue.

Considering the equilibrium reaction above, the green solution turns blue, as the concentration of H3O+ decreases and the indicator equilibrium shifts to the right.

When a strong acid is added, the reaction in (b) occurs. Considering the equilibrium reaction above, the green solution turns yellow, as the equilibrium shifts to the left as the concentration of H3O+ increases.

Hence the green solution can act as an indicator as it is a different colour in acidic and basic solutions; i.e. in solutions of different pH.

Question 34 (10 marks)

34 (a) (8 marks)

Outcomes Assessed: CH12–5, CH12–7, CH12–14

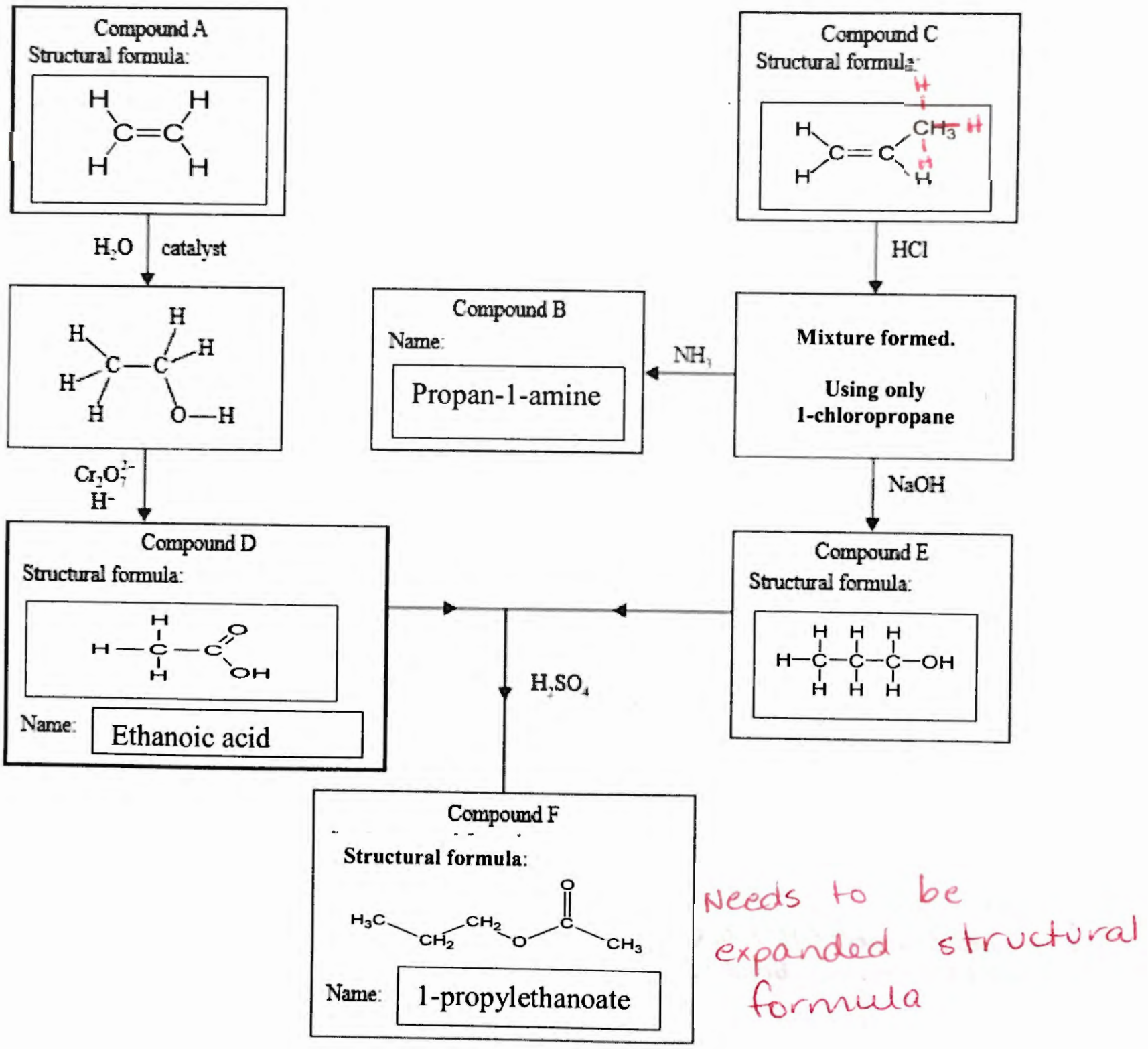
Targeted Performance Bands: 3

Criteria	Marks
• Completes 8 structural formulae or names	8

• Completes 7 structural formulae or names	7
• Completes 6 structural formulae or names	6
• Completes 5 structural formulae or names	5
• Completes 4 structural formulae or names	4
• Completes 3 structural formulae or names	3
• Completes 2 structural formulae or names	2
• Completes 1 structural formula or name	1

Sample answer

Compounds B and F may be synthesised as follows.



34 (b) (2 marks)
Outcomes Assessed: CH12–7, CH12–14
Targeted Performance Bands: 4-5

Criteria	Marks
• TWO correct answers	2
• ONE correct answer	1

Sample answer

Hydrohalogenation accepted

- Compound C is converted to 1-chloropropane in an **addition** reaction (Note for teachers: the addition reaction produces a mixture of 1-chloropropane and 2-chloropropane. 1-chloropropane is the minor product (see Markovnikoff's Rule).)
- 1-chloropropane is converted to Compound E in a **substitution** reaction.

Question 35 (5 marks)
32(a) (2 marks)
Outcomes Assessed: CH12–6, CH12–7, CH12–14
Targeted Performance Bands: 4-6

Marking Guidelines	Marks
• Shows structural formulas for 1-pentanol AND acetic acid with correct name	2
• Shows a structural formula for 1-pentanol ~~OR~~ AND acetic acid	1

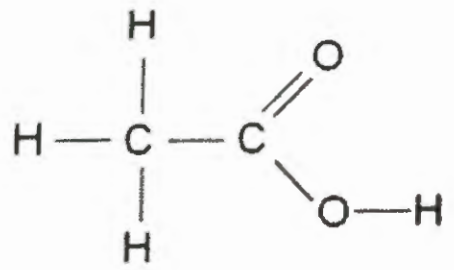
OR gives correct names for both OR gives 1 correct name + 1 correct structure

Sample answer

pentan-1-ol

Pentanol accepted for this question because ester was not identified as 1-pentyl ethanoate.

ethanoic acid (acetic acid)



35(b) (3 marks)
Outcomes Assessed: CH12–6, CH12–12, CH12–14
Targeted Performance Bands: 3-4

Marking Guidelines	Marks
• Thoroughly explains TWO reasons for using the reflux technique	3

• Explains TWO reasons for using the reflux technique with some detail missing	2
• Explains ONE reason for using the reflux technique	1

Sample answer
The reaction mixture is boiled under reflux, using an open condenser. This enables the reaction to be carried out at the boiling point, to maximise rate, without loss of volatile reactants or products via vaporisation. The use of an open condenser avoids any hazardous build-up of pressure in the system.

- Important to identify the equipment.

  Don't use : cooling tube
  heating mat) etc.

- Alkanols are the most volatile species in the reaction