SHORE

Exam Number: ☐☐☐

Year 12

Chemistry

Trial Examination

2020

General instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Board approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Write your Student Exam Number where required
- **Note:** Any time you have remaining should be spent revising your answers

Total marks – 100

Section 1

20 marks

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

Section 2

80 marks

- Attempt Questions 21 - 31
- Allow about 2 hours and 25 minutes for this section

DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

Section 1 – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

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

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1 An understanding of Le Chatelier's Principle is useful in the chemical industry. The prediction that can be made using this principle is the effect of

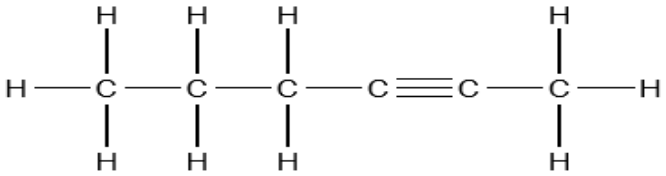
A. catalysts on the rate of reaction.

B. catalysts on the position of equilibrium.

C. changes in temperature on the rate of reaction.

D. changes in the concentration of reactants on the position of equilibrium.

2



The correct name of the compound above is

A. hex-4-yne

B. hex-2-yne

C. hex-2-ene

D. hept-2-yne

3 Which list contains only polymers produced by addition reactions of monomers?

A. Polyethylene, polyester, polystyrene

B. Polyvinyl chloride, polyester, polyethylene

C. Polyester, cellulose, polyethylene

D. Polyethylene, PVC, polystyrene

4 How many different structural isomers are there for C_3H_6BrCl?

A. 2

B. 3

C. 4

D. 5

5 The conjugate base of the ammonium ion is

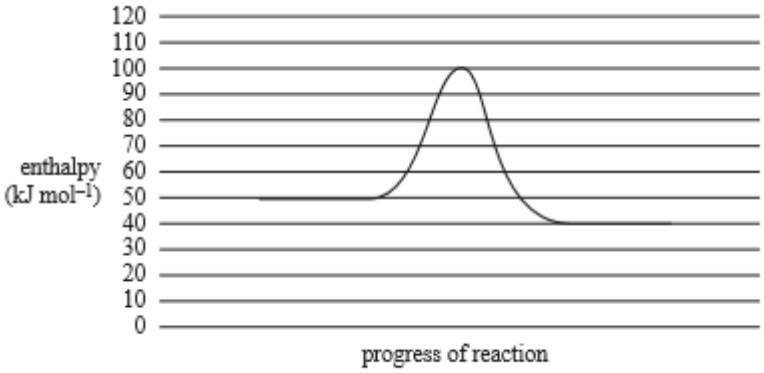
A. NH_3

B. NH_4

C. NH_2^-

D. NH_3^+

6 A reaction has the energy profile diagram shown below:



Which of the following represents the energy profile of the reverse reaction?

	Final product energy (kJ mol^{-1})	***ΔH (kJ mol^{-1})***
A.	40	+10
B.	50	+10
C.	50	-10
D.	40	-10

7 How many products are possible when but-2-ene reacts with HCl *(g)*?

A. 1

B. 2

C. 3

D. 4

8 For the reaction:

$$Br_2\ (g)\ +\ I_2\ (g)\ \rightleftharpoons\ 2IBr\ (g) \qquad K_{eq} = 1.2 \times 10^2 \text{ at } 150°C$$

Given this reaction above, what is the K_{eq} for the reaction shown below?

$$2IBr\ (g)\ \rightleftharpoons\ Br_2\ (g)\ +\ I_2\ (g) \text{ at } 150°C$$

A. 1.6×10^{-2}

B. 4.1×10^{-3}

C. 8.3×10^{-3}

D. 6.9×10^{-5}

9 A student wants to use a physical property to distinguish between two alcohols, octan-1-ol and propan-1-ol. Both alcohols are colourless liquids at standard laboratory conditions. The student should use

A. density because propan-1-ol has a much higher density than octan-1-ol.

B. boiling point because octan-1-ol has a higher boiling point than propan-1-ol.

C. electrical conductivity because octan-1-ol has a higher conductivity than propan-1-ol.

D. spectroscopy because it is not possible to distinguish between the alcohols using their other physical properties.

10 A compound with the formula $C_6H_{12}O_2$ has the following features:

- It is unbranched.
- It has only one type of functional group.
- All carbon-to-carbon bonds are single bonds.

The compound could be classified as an

A. ester.

B. amide.

C. alcohol.

D. aldehyde.

11 Nitric acid completely dissociates in aqueous solutions. 1.0 mL of 10 mol L^{-1} solution was diluted to 1 L with distilled water. 100 mL of this resulting solution was then further diluted to 1 L using distilled water.
What pH is the final solution closest to?

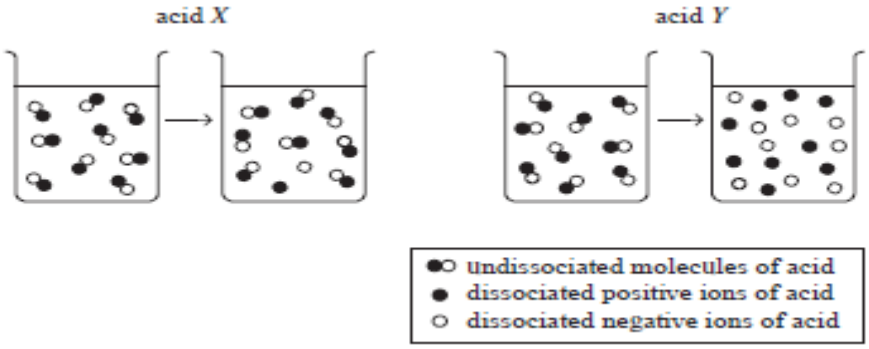
A. 1

B. 2

C. 3

D. 4

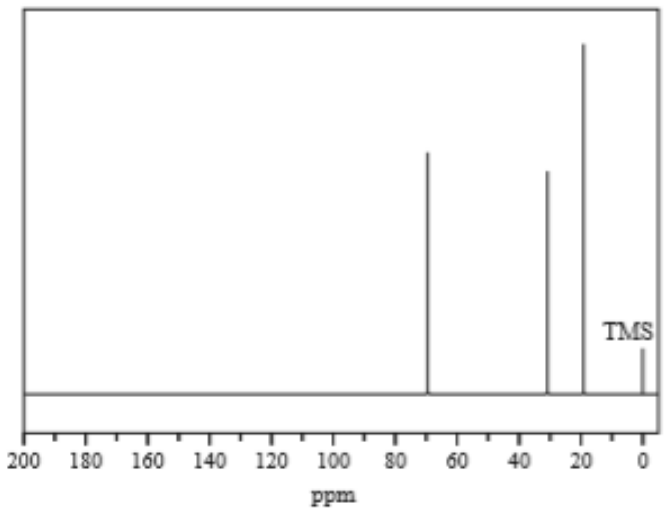
12 The diagram shows the behaviour of two different acids when they are dissolved in distilled water.



Which row of the table correctly describes the two acids?

	Acid X	***Acid Y***
A.	concentrated	dilute
B.	dilute	concentrated
C.	strong	weak
D.	weak	strong

13



The ^{13}C NMR spectrum above corresponds to which one of the following compounds?

A. Propane

B. 2-methylbutane

C. 2-methylpropan-2-ol

D. 2-methylpropan-1-ol

14 The equation describes an equilibrium reaction occurring in a closed system.

$$P\ (g) + Q\ (g) \rightleftharpoons 4R\ (g) \qquad \Delta H = +48\ kJ$$

Under which set of conditions would the highest yield of R be obtained?

	Temperature (°C)	***Pressure (kPa)***
A.	150	200
B.	150	400
C.	300	200
D.	300	400

15 A student mixed 20.0 mL of 0.0800 mol L^{-1} H_2SO_4 with 25.0 mL of 0.35 mol L^{-1} KOH.

What is the pH of the resulting solution?

A. 0.80

B. 0.91

C. 13.09

D. 13.20

16 Which of the following solutions, upon mixing will produce the solution with the highest temperature change?

A. 100 mL of 0.050M HNO_3 + 200 mL of 0.4M NaOH

B. 200 mL of 0.05M CH_3COOH + 50 mL of 0.2M NaOH

C. 50 mL of 0.1M H_2SO_4 + 100 mL of 0.4M KOH

D. 100 mL of 0.2M HCl + 50 mL of 0.25M $Ba(OH)_2$

17 An organic compound has a molar mass of 88 g mol^{-1}.
The ^{1}H NMR spectrum of the organic compound shows four distinct peaks.
The organic compound is most likely

A. butan-1-ol.

B. 2-methylbutan-1-ol.

C. 2-methylbutan-2-ol.

D. 2,2-dimethylpropan-1,3-diol.

18 The infrared spectrum of a pure compound showed:

- a very broad band between 2500 and 3000 cm^{-1}
- a series of moderate bands at 2900, 2990 and 3200 cm^{-1}
- an intense band at 1725 cm^{-1}
- numerous bands between 1640 and 750 cm^{-1}

Which of the following compounds matches these absorbances?

A. ethene

B. ethanol

C. ethyl ethanoate

D. ethanoic acid

19 The oxidation of sulfur dioxide, SO_2, to sulfur trioxide, SO_3, can be represented by the following equation:

$2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$ $\quad K_{eq} = 1.75$ at 1000°C

An equilibrium mixture has a concentration of 0.12 M SO_2 and 0.16 M oxygen gas, O_2.
The temperature of the container is 1000°C.

The equilibrium concentration of SO_3 at 1000°C is

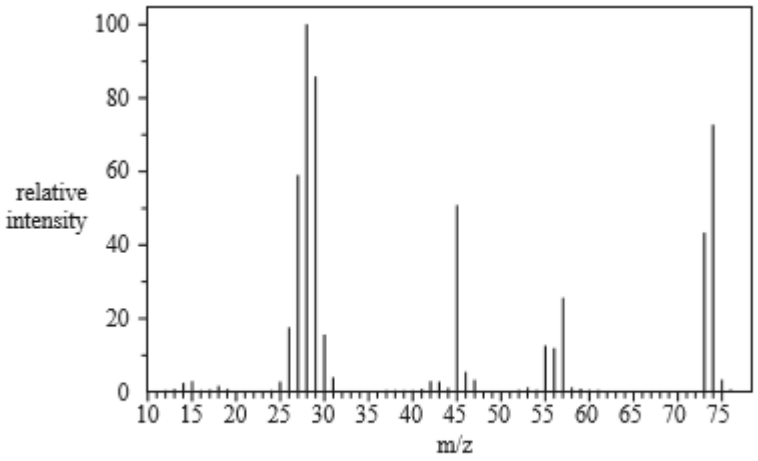
A. 1.5×10^{-4} M

B. 4.0×10^{-3} M

C. 1.2×10^{-2} M

D. 6.3×10^{-2} M

20 The mass spectrum of propanoic acid, CH_3CH_2COOH, is shown below.



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

The peak at m/z 74

A. represents the parent ion containing the carbon-13 isotope.

B. represents the species $[CH_3CH_2COOH]^+$.

C. represents the species CH_3CH_2COOH.

D. is commonly known as the base peak.

END OF SECTION 1

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Exam Number: ☐ ☐ ☐

2020 Chemistry Trial Examination

Section 2 – 80 marks
Attempt Questions 21–31
Allow about 2 hours and 25 minutes for this section

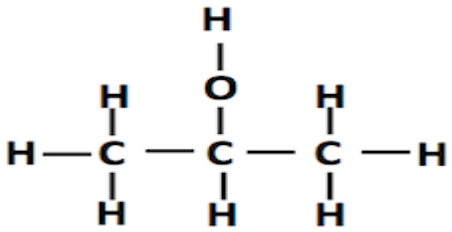
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

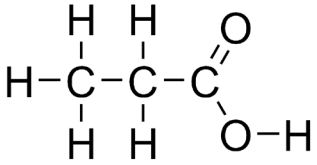
Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (11 marks)

The structures of 2 organic compounds, A and B, are shown below.



Compound **A**



Compound **B**

(a) Name compounds **A** and **B**. **2**

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(b) Identify an isomer of **A** which can be converted to compound **B**. **1**

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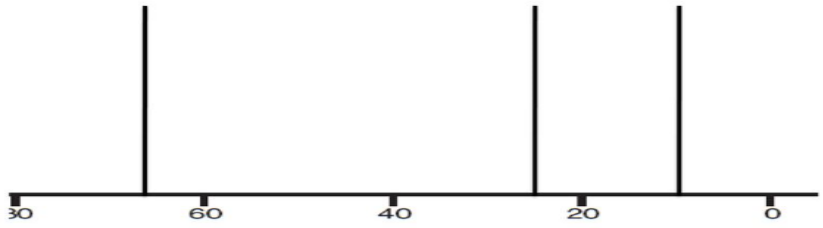
(c) Draw the structural formula of the organic compound, **C**, which is formed when compound **A** is oxidised using acidified potassium dichromate solution and name this compound **C**. **2**

Question 21 continues on the next page

(d) A student discovered a ^{13}C NMR spectrum, shown below, which claimed to be that of compound A. His teacher told him that the claim was incorrect. **3**



Justify why the claim is incorrect and include a diagram to predict the correct ^{13}C NMR spectrum for compound A.

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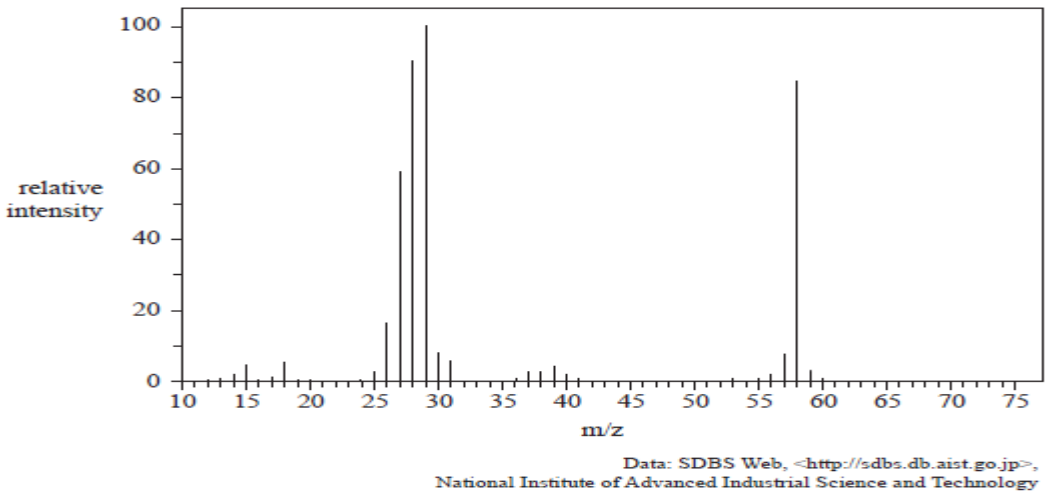
(e) The mass spectrum below was produced by an organic molecule of formula C_3H_6O and was known to be an alkanone or an alkanal. **3**



Data: SDBS Web, <http://sdbs.db.aist.go.jp>, National Institute of Advanced Industrial Science and Technology

(i) Identify the fragment at 29 m/z.

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Question 21 continues on the next page

Question 21 (continued)

(ii) Identify the molecule and justify your answer.

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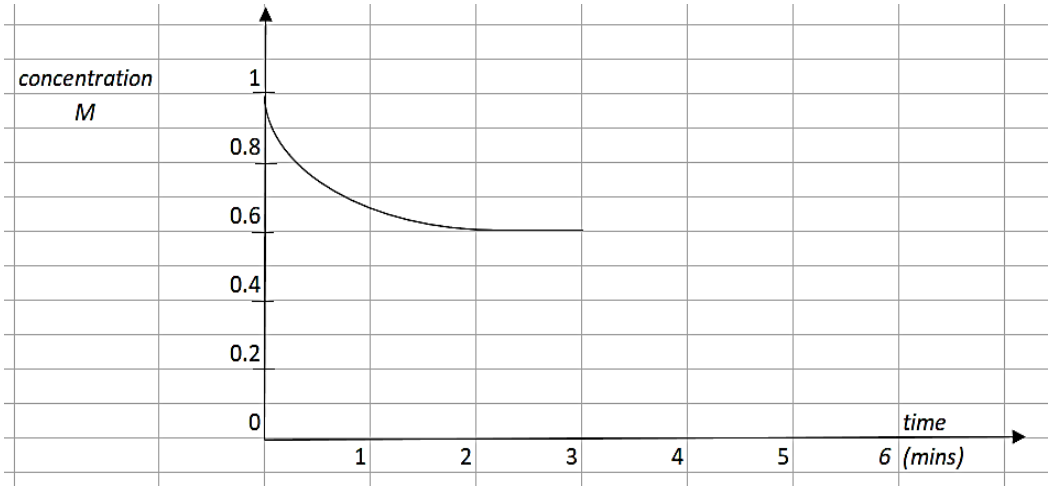
Question 22 (3 marks)

Sulfur trioxide is an unstable gas that can decompose according to the equation:

$$2SO_3\,(g) \rightleftharpoons 2SO_2\,(g) + O_2\,(g) \qquad \Delta H > 0$$

(a) A sample of sulfur trioxide gas was added to an empty sealed flask and its concentration was measured over the next 3 minutes. **2**

The SO_3 concentration is plotted on the graph below.



Draw on the graph the corresponding concentrations for the sulfur dioxide and oxygen gases during the first 3 minutes.

(b) At the 3-minute mark the temperature of the system is increased. On the graph provided in part (a), show the impact of this change on the SO_3 concentration.

1

Question 23 (12 marks)

Ethanoic acid, CH_3COOH, is the active ingredient in white vinegar. A sample of white vinegar is analysed to accurately determine the concentration of CH_3COOH using the following steps:

Step 1 – Dilute a 10.00 mL sample of the white vinegar to 100.00 mL in a volumetric flask.
Step 2 – Rinse the burette with the standardised sodium hydroxide solution, NaOH, that is provided.
Step 3 – Fill the burette with the standardised NaOH solution.
Step 4 – Pipette 20.00 mL of the diluted white vinegar solution into a 250 mL conical flask.
Step 5 – Add several drops of phenolphthalein indicator to the conical flask. Titrate the diluted white vinegar solution against the standardised NaOH solution.
Step 6 – Repeat Steps 3–5 until concordant results are obtained.

The equation for this analysis is:

$$CH_3COOH\ (aq) + NaOH\ (aq) \rightarrow CH_3COONa\ (aq) + H_2O\ (l)$$

Data

aliquot of diluted white vinegar solution	20.00 mL
mean titre of NaOH solution	25.60 mL
concentration of standardised NaOH solution	0.1123 M

(a) Calculate the concentration of CH_3COOH in the undiluted white vinegar sample. **3**

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Question 23 continues on the next page

Question 23 (continued)

(b) If the burette is rinsed with water instead of the standardised NaOH solution, what would be the effect, if any, on the experimental value obtained for the concentration of CH_3COOH in white vinegar? Justify your answer. **2**

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(c) Phenolphthalein was used as the indicator for this titration. Justify its use by referring to the final pH of the solution. Include a relevant equation. **3**

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(d) CH_3COOH is a weak acid and has an acid dissociation constant of 1.8×10^{-5}. **2**

Write the equation for the ionisation of ethanoic acid in water.

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Write the expression for K_a for ethanoic acid.

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Question 23 continues on the next page

(e) An alternative method of determining the concentration of CH_3COOH in white vinegar is to measure the pH of the vinegar. Using a digital probe, the undiluted vinegar is found to have a pH of 2.31. Given the K_a for ethanoic acid in part (c) above, calculate the concentration of the ethanoic acid in the undiluted vinegar solution using this method. **2**

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Exam Number: ☐ ☐ ☐

Question 24 (12 marks)

(a) Write an equation for the reaction of solutions of lead (II) nitrate and sodium hydroxide. **1**

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(b) Using the solubility product information from the data pages, determine which of lead (II) hydroxide and lead (II) carbonate has the greater solubility in water, in units of mol/L, at 25ºC. **4**

Show all working and reasoning.

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(c) Would a precipitate of lead carbonate form if 50 mL of 2.0×10^{-4} mol/L sodium carbonate were added to a solution of 150 mL of 5.0×10^{-3} mol/L lead (II) nitrate? Show all working and reasoning. **3**

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Question 24 continues on the next page

Question 24 (continued)

(d) A lump of solid lead (II) carbonate, which contained radioactive lead ions, was added to a saturated solution of lead (II) carbonate and left to stand for several hours. Predict the distribution of the radioactive lead (II) ions after some hours and explain your prediction. **2**

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(e) Use the example in part (d) above to explain the difference between a static and dynamic equilibrium. **2**

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Question 25 (8 marks)

The table shows the acid dissociation constants at 25ºC.

Acid	Formula	K_a
Ethanoic 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_6OH	1.3×10^{-10}

Refer to the above table for Question 25 (a) to (c)

(a) Identify the weakest 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 M solution of hydrocyanic acid. **2**

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Question 25 continues on the next page

(c) A buffer solution is prepared by combining 100 mL of 0.10 M HCN and 100 mL of 0.10 M NaCN.

(i) Explain why this solution forms a buffer. **1**

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(ii) Calculate the pH of this buffer solution **3**

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Question 26 (8 marks)

A change in the position of equilibrium can be demonstrated visually using two forms of cobalt (II) ions. Solutions of the $Co(H_2O)_6^{2+}$ ion are pink and solutions of the $CoCl_4^{2-}$ ion are blue.
A solution made from 0.5 M $Co(H_2O)_6^{2+}$ ions and 5 M Cl^- ions reaches the following equilibrium.

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}\,(aq)} + 4Cl^-\,(aq) \rightleftharpoons \underset{\text{blue}}{CoCl_4^{2-}\,(aq)} + 6H_2O\,(l)$$

At room temperature, the mixture is blue when this solution is at equilibrium.

(a) Write the equilibrium expression, K_{eq}, for the equation above. **1**

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(b) One 20 mL sample is diluted by adding 10 mL of deionised water, H_2O, at room temperature. The solution immediately becomes a paler blue due to the dilution. Use Le Chatelier's principle to explain the colour change expected from this paler blue colour until a new equilibrium is reached. **2**

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Question 26 continues on the next page

(c) 10 g of $AgNO_3$ crystals is mixed into a second 20 mL sample of the equilibrium mixture. What effect will the addition of $AgNO_3$ crystals to the second solution have on the position of equilibrium?
(Assume that there is no significant reaction between the $AgNO_3$ and the $CoCl_4^{2-}$).

(i) Write an equation for the reaction involving $AgNO_3$. **1**

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(ii) Explain your answer in terms of collision theory. **2**

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(d) Samples of the original equilibrium solution are pink when refrigerated at 4°C and blue when kept at 25°C. **2**
Is the reaction in the original equilibrium solution endothermic or exothermic?
Explain your reasoning.

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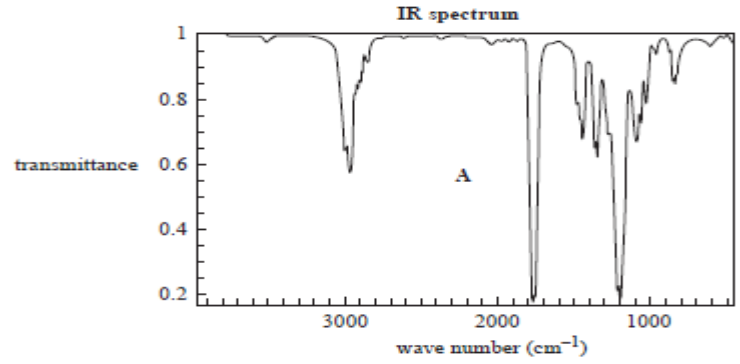
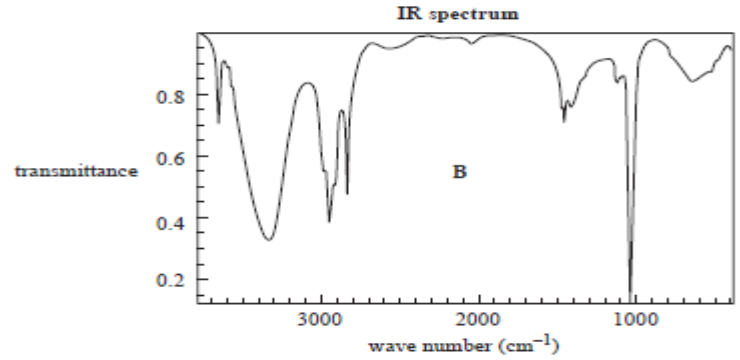
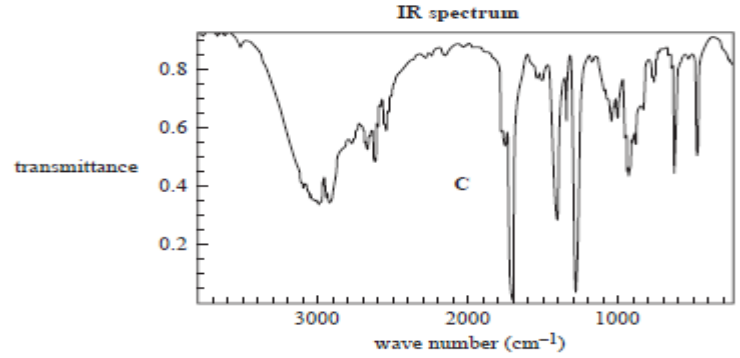
Exam Number: ☐☐☐

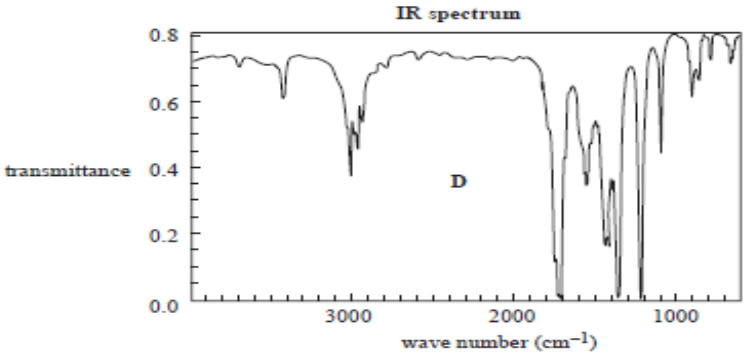
Question 27 (6 marks)

A student prepared the compound ethyl pentanoate in a school laboratory using two organic reactants. The infra-red (IR) spectra for the two reactants and two other related compounds are given below.









Question 27 continues on the next page

Question 27 (continued)

(a) Name and draw the structural formulae for each of the organic reactants used to produce ethyl pentanoate. **3**

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(b) For **each** of the reactants named in **part (a) above,** identify its corresponding IR spectrum from spectra A to D shown on page 23. **2**
Justify your answer using data from the spectrum.

Reactant ……. Spectrum…… ….

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Reactant ……. Spectrum…… ….

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(c) Draw the structural formula of ethyl pentanoate in the space provided below. **1**

Question 28 (5 marks)

The industrial production of nitric acid involves several equilibrium steps.

One step in the production of nitric acid involves the reaction of nitrogen monoxide with oxygen, according to the equation:

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

(a) This reaction is exothermic.
Justify TWO methods which could be used to increase the yield of nitrogen dioxide. **2**

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(b) A 10 L reaction flask initially contained 2.5 mol NO and 1.2 mol O_2. After equilibrium was established, there was only 0.5 mol NO.

Calculate the equilibrium constant for the reaction. Show all relevant working. **3**

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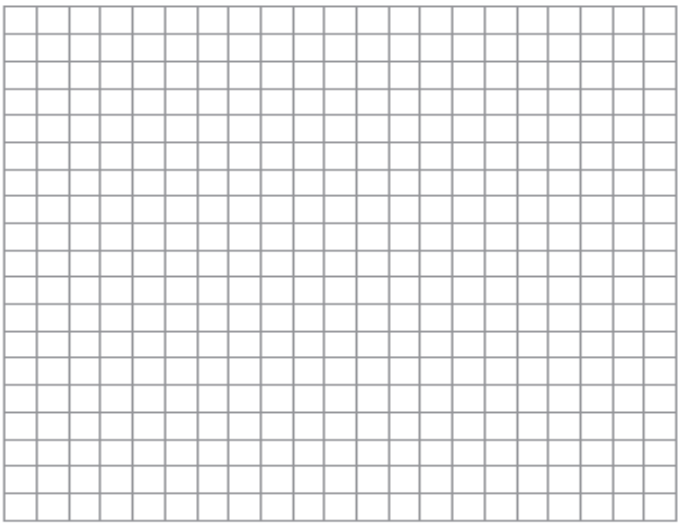
Question 29 (5 marks)

An ore sample containing bismuth was analysed using atomic absorption spectroscopy (AAS). Standard solutions of bismuth were used to calibrate the spectrometer and the following data were recorded:

Bismuth concentration (ppm)	Absorbance
0.0	0.00
5.0	0.25
10.0	0.56
15.0	0.81
20.0	1.08

(a) Using the data in the table above, plot a calibration line on the grid below, **2**



(b) The absorbance of the sample containing bismuth was found to be 0.51. Determine the concentration, in ppm, of bismuth in the sample. **1**

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(c) Explain why other trace elements in the sample will not interfere with the AAS analysis of bismuth. **2**

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Question 30 (4 marks)

Explain how the properties of sodium salts of long chain fatty acids help to clean grease from dirty dishes. Draw a diagram of a micelle to support your answer. **4**

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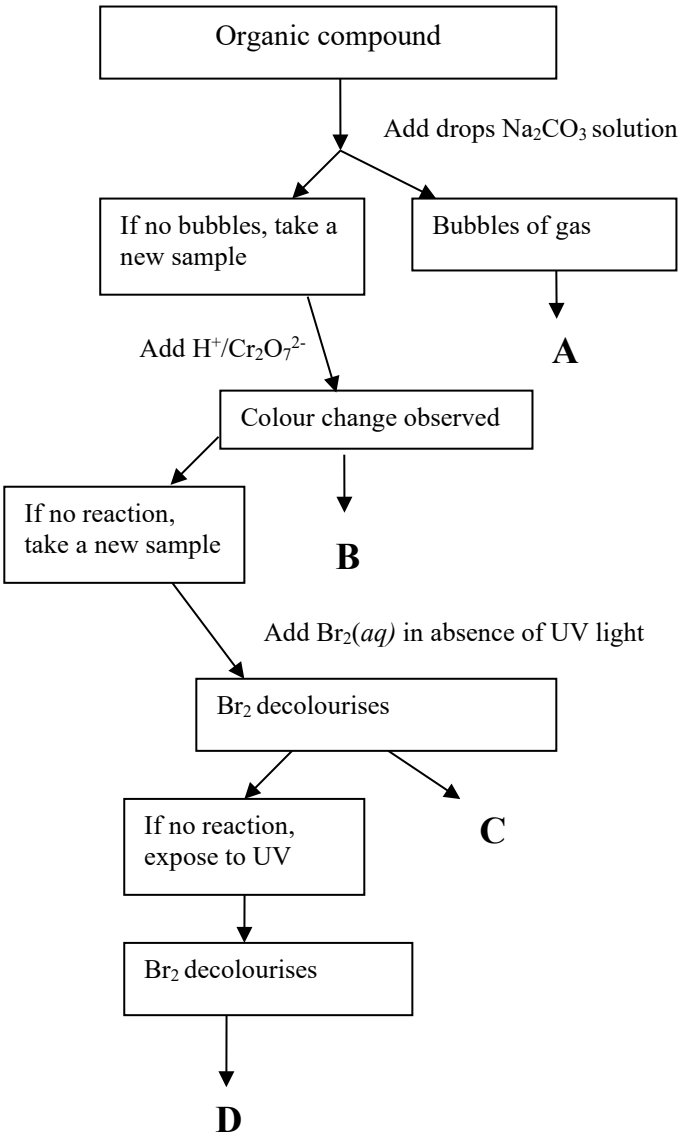
Question 31 (6 marks)

A student designed a flowchart to distinguish between samples of an alkene, alkane, alcohol and organic acid.
Use the flowchart to answer the questions below:



(a) Identify the type of compound for each of A, B, C, D. **2**
Choose from alkene, alkane, alcohol and acid.

A = …… B = ……

C = …… D = ……..

Question 31 continues on the next page

Question 31 (continued)

(b) Write the equation (using structural formulae for the organic compounds) for the reaction which identifies **A**. Use an example of a 2-carbon compound in your answer to draw compound **A**. **2**

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(c) Write the equation (using structural formulae for the organic compounds) for the reaction which identifies **C**. Use an example of a 2-carbon compound in your answer. Name the organic product formed. **2**

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End of paper

Section 2 – Extra writing space

If you use this space, clearly indicate which question you are answering.

Section 2 – Extra writing space

If you use this space, clearly indicate which question you are answering.

SHORE

Exam Number:

Year 12

V7 UPDATED 4/9/2020

Chemistry

Trial Examination – Suggested Answers and Marking Guidelines

2020

General instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Board approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Write your Student Exam Number where required
- **Note:** Any time you have remaining should be spent revising your answers

Total marks – 100

Section 1

20 marks

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

Section 2

80 marks

- Attempt Questions 21 - 38
- Allow about 2 hour and 25 minutes for this section

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Explanations for Multiple Choice	
1	**D**. Le Chatelier's Principle predicts the shift in equilibrium, not the rate of reaction. The shift is recognised by the changes in the proportions of reactants and products.
2	**B**. Hex-2-yne - 6 carbons so hex… then count from the RHS to give lowest number for functional group
3	**D.** Polyethylene, PVC and polystyrene all form by addition reactions involving the C=C bonds in the monomers. Polyesters form by monomers with -OH and -COOH groups reacting and linking the monomers, with water being split out. Hence condensation.
4	**D**. 1-bromo-1-chloropropane 1-bromo-2-chloropropane 1-bromo-3-chloropropane 2-bromo-2-chloropropane 1-chloro-2-bromopropane
5	**A**. NH_3 is formed when the acid, NH_4^+, loses one proton (H^+).
6	**B**. The enthalpy change for the reverse reaction = 50 – 40 = +10 kJ mol^{-1}. The final product energy for the reverse reaction is 50 kJ mol^{-1}
7	**A**. But-2-ene is a symmetrical molecule with the double bond between carbons 2 and 3. When H–Cl adds into the molecule only one product is formed, 2-chlorobutane.
8	C. The equation is reversed and the moles of each reactant and product doubled. $K_2 = 1/(K_1)^2 = 1/(1.2 \times 10^2)^2 = 1/(1.44 \times 10^4) = 0.69 \times 10^{-4} = 6.9 \times 10^{-5}$
9	**B**. Octan-1-ol has a longer chain than propan-1-ol, so will have greater dispersion forces and will be a heavier molecule – hence a higher boiling point.
10	**A**. Of the options given, only an ester fits the features listed and has the general formula, $C_nH_{2n}O_2$. It has 2 O atoms. It cannot be an amide, as no N atoms, and cannot be an alcohol or an aldehyde as they have only 1 O atom per molecule.

11	**C**. The original acid solution was diluted by a factor of 10^4. Hence the diluted solution has a concentration of $10/10^4 = 1.0 \times 10^{-3}$ mol/L If $[H^+] = 1 \times 10^{-3}$ $pH = -\log_{10} (1 \times 10^{-3}) = 3.0$
12	**D.** The diagrams for both acids show nine molecules in the same volume; hence both acid solutions have the same initial concentration. Only one of the nine molecules of acid ***X*** dissociates, so ***X*** is a weak acid. All nine molecules of acid ***Y*** dissociate (dissociates completely), so ***Y*** is a strong acid. The terms 'concentrated' and 'dilute' describe the amount of acid in the solution, NOT the degree of dissociation of the acids themselves.
13	**D.** 3 peaks so 3 carbon environments - CH_3, CH_2 and CH
14	**C.** By Le Chatelier's Principle, the highest yield of the product R, will be at the highest temperature (as the forward reaction is endothermic) but at the lowest pressure (as there are more moles of gas on the RHS of the equation).
15	**C** No. of moles of $H^+ = (20/1000) \times 0.0800 \times 2 = 0.0032$ mol H^+ No of moles of $OH^- = (25/1000) \times 0.35 = 0.00875$ mol OH^- After mixing and neutralisation, there are excess moles of OH^-. Moles of OH^- in excess = 0.00875 – 0.0032 = 0.00555 mol $[OH^-] = 0.00555$ mol /0.045 L = 0.1233 mol/L $pOH = -\log_{10} (0.1233) = 0.9090$ pH = 14.000 – 0.909 = 13.09 (Since the data given was only accurate to 2 s.f., the pH should be expressed to 2 d.p.)

16	**D** Mixture A contains 0.005 mole of H^+ and 0.08 moles OH^-. This combination will produce 0.005 moles water by neutralisation in a total volume of 300 mL. Mixture B 0.01 moles of CH_3COOH and 0.01 moles of OH^-. This combination will produce 0.01 moles water by neutralisation in a total volume of 250 mL. Mixture C contains 0.015 moles of H^+ (H_2SO_4 is diprotic) and 0.04 moles OH^-. This combination will produce 0.015 moles water by neutralisation in a total volume of 150 mL. Mixture D contains 0.02 moles of H^+ and 0.025 moles OH^- ($Ba(OH)_2$ has 2 moles OH^- per mole of $Ba(OH)_2$). This combination will produce 0.02 moles water by neutralisation in a total volume of 150 mL. Mixture D produces the greatest no. of moles of water, in the equal smallest volume (150 mL). Neutralisation is exothermic, with the amount of heat liberated (to heat the water) being proportional to the no. of moles of water formed when equal volumes of final solution are involved. Hence the greatest increase in temperature will occur in D.
17	**C.** The no. of peaks is determined by the no. of different hydrogen environments. Butan-1-ol (A) ($C_4H_{10}O$) will show five distinct peaks on their 1H NMR spectra and has a molar mass of 74. 2-methylbutan-1-ol (B) ($C_5H_{12}O$) would show 6 peaks and has a MM of 88. 2-methylbutan-2-ol (C) ($C_5H_{12}O$) would show 4 peaks and has a MM of 88. (the 2 CH_3's attached to the C-OH would be 1 peak) 2,2-dimethylpropan-1,3-diol (D) would show 3 peaks as it is symmetrical with a MM of 92.

18	**D**. The presence of a broad band between 3000 and 3500 cm^{-1} indicates the presence of an –OH group. The strong absorbance at 1725 cm^{-1}indicates the presence of a carbonyl group (C=O). Ethanoic acid is the only option that would produce both these absorbance bands.
19	**D.** $K = [SO_2]^2 / [SO_3]^2[O_2]$ $[SO_3]^2 = K \times [SO_2]^2[O_2] = 1.75 \times (0.12)^2 \times 0.16 = 4.03\times10^{-3}$ $[SO_3] = \sqrt{(4.03\times10^{-3})} = 6.3 \times 10^{-2}$ mol/L Option B was consistent with not following though to the last step of finding the square root.
20	**B**. The parent ion is at 74 and is the fragment formed when the total molecule loses 1 electron. Here the molecular ion is formed – $[CH_3CH_2COOH]^+$.

Section II – 80 marks

Question 21 (11 marks)

21 (a) (2 marks)

Outcomes Assessed: CH12–7, CH12–14

Targeted Performance Bands: 2-3

Criteria	Marks
• Correctly names TWO compounds	2
• Correctly names ONE compound	1

Sample answer

A = propan-2-ol

B = propanoic acid

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21 (b) (1 mark)

Outcomes Assessed: CH12–7, CH12–14

Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies propan-1-ol	1

Sample answer

Propan-1-ol (by name or correct formula)

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21 (c) (2 marks)

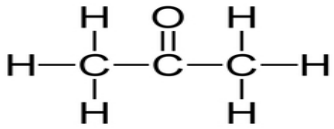
Outcomes Assessed: CH12–7, CH12–14

Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies propanone as compound **C** AND draws the correct structure	2
• Identifies propanone as compound **C** OR draws the correct structure	1

Sample answer

Propanone or Propan-2-one

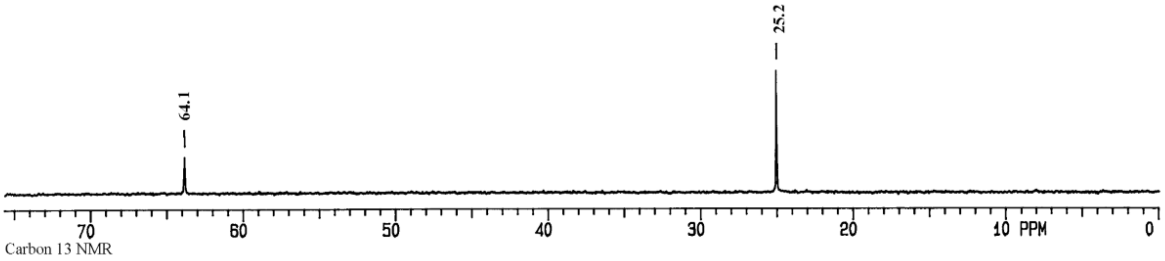


21 (d) (3 marks)
Outcomes Assessed: CH12–5, CH12–7, CH12–15
Targeted Performance Bands: 3-6

Criteria	Marks
• Justifies that the spectrum cannot be that of compound A on the basis that compound A has only 2 different carbon environments and the spectrum shows 3 lines, indicating 3 different carbon environments AND • Includes a diagram which shows only 2 lines on the spectrum AND • Shows 1 line in the low shift range and 1 in the high shift range	**3**
• TWO of the above	**2**
• ONE of the above	**1**

Sample answer
The spectrum cannot be that of compound A on the basis that compound A has only 2 different carbon environments as the 2 terminal carbons have the same environment. The spectrum shows 3 lines, indicating 3 different carbon environments

Note for teachers: Only requires a rough sketch showing 2 lines, 1 in higher shift range, 1 in lower shift range.



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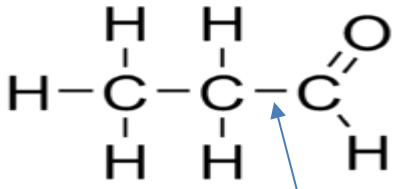
21 (e) (3 marks)
Outcomes Assessed: CH12–6, CH12–7, CH12–15
Targeted Performance Bands: 3-6

Criteria	Marks
• Identifies the fragment at 29 m/z as $–CHO^+$ (or $–C_2H_5^+$) • Identifies the molecule as propanal • Justifies that the molecule as the alkanal (propanal) which contains a –CHO group while the alkanone (propanone) would have fragment at 43 m/z (not present on the spectrum)	3
• TWO of the above	2
• ONE of the above	1

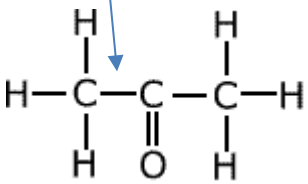
Sample answer
The possible compounds are propanal and propanone.

Propanal contains the terminal $–CHO^+$ group which will form the base peak at m/z = 29.
Also a fragment $–C_2H_5^+$ is possible with m/z = 29.



Propanal fragments here.

Propanone would not form a CHO^+ fragment or a $–C_2H_5^+$ fragment.
It would have fragments at m/z = 43 and m/z = 15 corresponding to formation of $CH_3C{=}O^+$ and $–CH_3^+$.
These are not present on the spectrum.
Propanone fragments here.



Hence the molecule is propanal.

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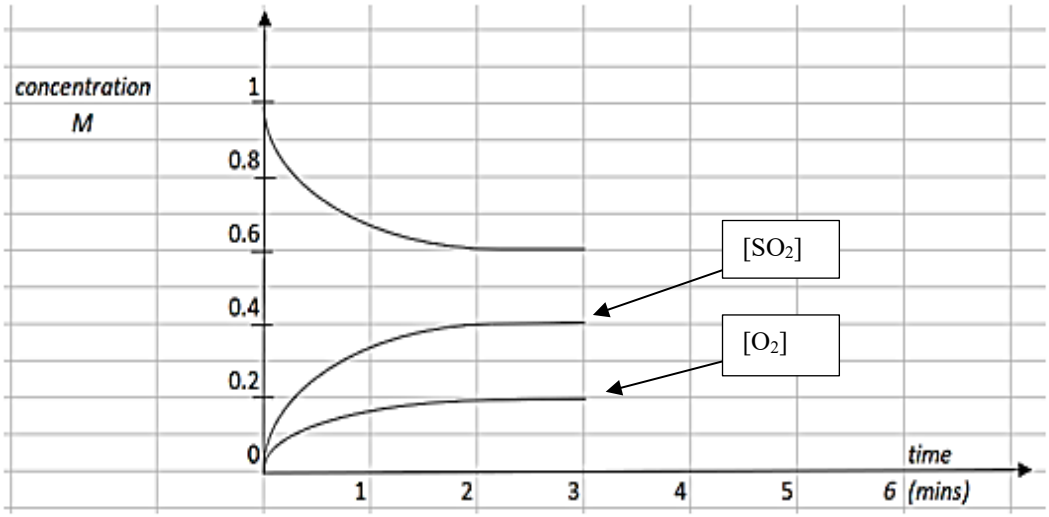
22 (a) (2 marks)
Outcomes Assessed: CH12–5, CH12–7, CH12–12
Targeted Performance Bands: 3-5

Criteria	Marks
• Shows the correct plots BOTH for sulfur dioxide and oxygen	2
• Shows the correct plot for ONE of sulfur dioxide and oxygen	1

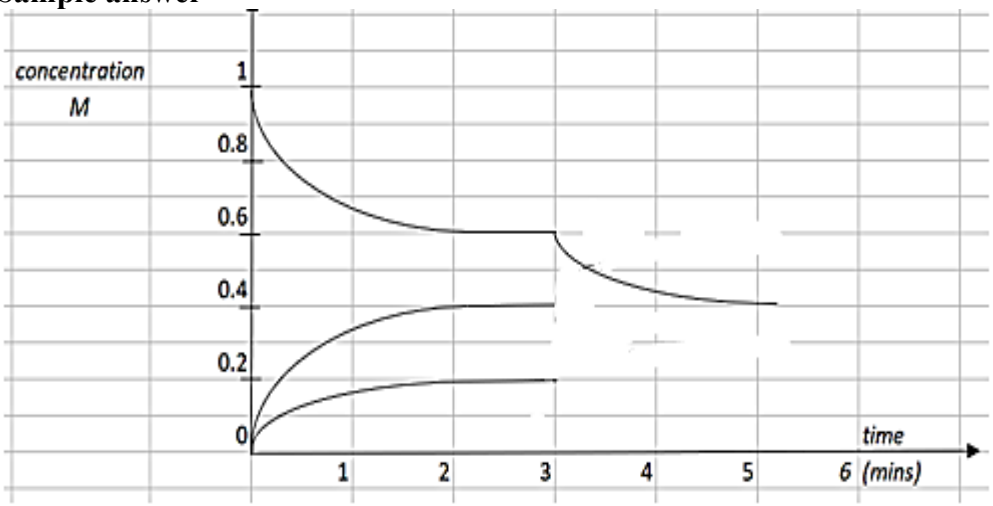
Sample answer



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

Criteria	Mark
• Shows the impact on the [SO_3] after the 3-minute mark	1

Sample answer



Question 23 (9 marks)
23 (a) (3 marks)
Outcomes Assessed: CH12–5, CH12–13
Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly calculates the concentration of acetic acid in the undiluted vinegar sample	3
• Calculates the concentration of acetic acid in the diluted vinegar sample	2
• Determines the moles of diluted vinegar in the conical flask	1

Sample answer
Moles NaOH added = cV = 0.1123 x 0.02560 = 0.002875 mol
Moles diluted vinegar = 0.002875 mol (same as NaOH as react in 1:1 ratio)
Concentration of diluted vinegar = n/V = 0.002875/0.0200 = 0.1438 M
Undiluted vinegar was diluted by a factor of 10.
Hence [CH_3COOH] in undiluted vinegar = 1.438 M.

---

23 (b) (2 marks)
Outcomes Assessed: CH12–3, CH12–5, CH12–7, CH12–13
Targeted Performance Bands: 3-5

Criteria	Marks
• Justifies why the experimental calculated concentration of acetic acid would have been too high • Identifies that the actual concentration of NaOH used in the titration would have been lower than that of the standardised solution because of the unknown amount of water present	2
• Identifies that the experimental calculated concentration would have been too high OR • Identifies that the actual concentration of NaOH used in the titration would have been lower than that of the standardised solution	1

Sample answer

The experimental calculated concentration of the acetic acid would been too high because the actual concentration of NaOH used in the titration would have been lower than that of the standardised solution because of the unknown amount of water present.

Water remaining in the burette dilutes the NaOH *(aq)* added to it, and so a larger volume of NaOH/larger titre would have been required to reach the endpoint of the reaction.

This inaccurate larger volume of NaOH would have led to the incorrect conclusion that the acetic acid concentration was higher than the actual concentration.

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23 (c) (3 marks)
Outcomes Assessed: CH12–5, CH12–13
Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly explains why phenolphthalein is the most suitable indicator to use referring to the pH of the final solution AND • the pH range of the indicator AND • providing a correctly written chemical equation	3
• Correctly explains why phenolphthalein is the most suitable indicator to use referring to the pH of the final solution AND • the pH range of the indicator OR • providing a correctly written chemical equation	2
• Correctly explains why phenolphthalein is the most suitable indicator to use referring to the pH of the final solution OR • the pH range of the indicator OR • providing a correctly written chemical equation	1

Sample answer

The final pH of the solution will be above 7 (around 8) due to the hydrolysis of the acetate (ethanoate) ion with water:

$$CH_3COO^- \ (aq) \ + \ H_2O \ (l) \rightleftharpoons OH^- \ (aq) \ + \ CH_3COOH \ (aq)$$

The indicator phenolphthalein changes from colourless to magenta (dark pink) over the range of 8.2 to 10 pH units. Since the pH of the final solution is around 8 phenolphthalein is the best indicator to use to show the endpoint of the titration.
A pOH calculation/ pH calculation was also awarded marks.

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23 (d) (2 marks)
Outcomes Assessed: CH12–4, CH12–7, CH12–13
Targeted Performance Bands: 2-4

Criteria	Marks
• Writes the correct equation for the ionisation of ethanoic acid in water AND • Writes the correct expression for the K_a for ethanoic acid	2
• Writes the correct equation for the ionisation of ethanoic acid in water OR • Writes the correct expression for the K_a for ethanoic acid	1

Sample answer

$CH_3COOH\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + CH_3COO^-\ (aq)$

$K_a\ CH_3COOH = \dfrac{[CH_3COO^-]\,[H_3O^+]}{[CH_3COOH]} = 1.8 \times 10^{-5}$

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23 (e) (2 marks)
Outcomes Assessed: CH12–5, CH12–13
Targeted Performance Bands: 3-5

Criteria	Marks
• Determines the concentration of acetic acid in white vinegar correctly to 2 s.f.	2
• Determines the concentration of acetic acid in white vinegar correctly but to other than to 2 s.f. OR • Determines the $[H^+]$ of the undiluted vinegar	1

Sample answer

If pH = 2.31, then $[H^+] = 10^{-pH} = 10^{-2.31} = 0.00490$ mol/L

Let x moles/L acetic acid dissociate to form 0.00490 mol/L H^+

$K_a\ (CH_3COOH) = \dfrac{[x]\,[x]}{[CH_3COOH - x]} = 1.8 \times 10^{-5}$

$K_a\ (CH_3COOH) = \dfrac{[0.00490]\,[0.00490]}{[CH_3COOH - 0.00490]} = 1.8 \times 10^{-5}$

Assume x is small by comparison with $[CH_3COOH]$

$[CH_3COOH] = (0.00490)^2 / 1.8 \times 10^{-5} = 1.3$ mol/L (only 2.s.f. justified)

Question 24 (12 marks)
24 (a) (1 mark)
Outcomes Assessed: CH12–7, CH12–12
Targeted Performance Bands: 2-3

Criteria	Mark
• Correct answer (showing correct states)	1

Sample answer
Pb^{2+} *(aq)* + $2OH^-$ *(aq)* → $Pb(OH)_2$ *(s)*

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24 (b) (4 marks)
Outcomes Assessed: CH12–6, CH12–7, CH12–12
Targeted Performance Bands: 3-6

Criteria	Marks
• Correctly demonstrates by calculation, with correct units and correct reasoning, that $Pb(OH)_2$ has greater solubility	4
• Correct expressions for K_{sp} $Pb(OH)_2$ AND K_{sp} $PbSO_4$ with correct reasoning but with ONE mathematical error	3
• A correct calculation for the solubility of ONE of $Pb(OH)_2$ OR $PbSO_4$	2
• Some evidence of correct understanding of how to determine the solubility of a salt given the K_{sp} value	1

Sample answer
Let the solubility of $Pb(OH)_2$ be s

K_{sp} $Pb(OH)_2 = [Pb^{2+}]\,[OH^-]^2 = (s)\,(2s)^2 = 4s^3 = 1.43 \times 10^{-15}$

$s^3 = 0.3575 \times 10^{-15}$ mol/L

$s = (0.3575)^{1/3} \times 10^{-5}$

$s = 0.710 \times 10^{-5}$

$s = 7.10 \times 10^{-6}$ mol/L

Hence solubility of $Pb(OH)_2 = 7.10 \times 10^{-6}$ mol/L

Let the solubility of $PbCO_3$ be s.

K_{sp} $PbCO_3 = [Pb^{2+}]\,[CO_3^{2-}] = (s)\,(s) = s^2 = 7.40 \times 10^{-14}$

$s = \sqrt{(7.40 \times 10^{-14})} = 2.72 \times 10^{-7}$ mol/L

The solubility of $PbCO_3 = 2.72 \times 10^{-7}$ mol/L

Hence the solubility of $Pb(OH)_2$ (in mol/L) is greater than the solubility of $PbCO_3$ (in mol/L).

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

Criteria	Marks
• Correct conclusion, showing correct working/reasoning	3
• Correct expression for $[Pb^{2+}]$ $[CO_3^{2-}]$ but incorrect conclusion	2
• Correct calculation of $[CO_3^{2-}]$ or $[Pb^{2+}]$	1

Sample answer

no. of moles $Na_2CO_3 = 2.0 \times 10^{-4} \times (50/1000) = 1.0 \times 10^{-5}$ mol

no. of moles $Pb(NO_3)_2 = 5.0 \times 10^{-3} \times (150/1000) = 7.5 \times 10^{-4}$ mol

Total volume of solution = 200 mL

$[CO_3^{2-}] = 1.0 \times 10^{-5} / 0.200 = 5.0 \times 10^{-5}$ mol/L
$[Pb^{2+}] = 7.5 \times 10^{-4} / 0.200 = 3.75 \times 10^{-3}$ mol/L

The product of the concentration of the ions is

$[Pb^{2+}]\ [CO_3^{2-}] = 3.75 \times 10^{-3} \times 5 \times 10^{-5} = 18.75 \times 10^{-9} = 1.9 \times 10^{-7}$

Since this product is greater than K_{sp} (7.40×10^{-14}), a precipitate will form.

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24 (d) (2 marks)
Outcomes Assessed: CH12–7, CH12–12
Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly predicts that the radioactive lead ions will be present both in the saturated solution and in the solid AND • Explains the prediction in terms of the dynamic equilibrium	2
• Correctly predicts that the radioactive lead ions will be present both in the saturated solution and in the solid	1

Sample answer
Initially, equilibrium exists between a saturated aqueous solution of lead (II) carbonate and solid crystals of lead (II) carbonate. The forward and backward reactions for the dissociation and formation of solid $PbCO_3$ are occurring in the beaker at the same rate.

The equilibrium was then disturbed by the addition of solid lead (II) carbonate containing ions of a lead (II) isotope which is radioactive. After some time, the saturated solution would contain lead (II) ions containing the radioactive isotope of lead. This proves that some of the solid had dissolved to form ions after the addition of the radioactive solid. Sampling of the solid in the beaker would also show both stable and radioactive lead (II) sulfate. This means that the added radioactive solid was now, after the establishment of the new equilibrium, distributed both in the saturated solution and the solid. Testing of the solution over time should show a percentage of the stable and radioactive isotope. The solid should also show this same percentage. This proves that the reversible reactions have occurred and are still occurring after the reestablishment of equilibrium.

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24 (e) (2 marks)
Outcomes Assessed: CH12–7, CH12–12
Targeted Performance Bands: 3-5

Criteria	Marks
• Identifies the equilibrium between a solid and its ions, in a saturated solution, as dynamic AND • Explains the meaning of a static equilibrium AND • Explains the meaning of a dynamic equilibrium	2
• Identifies the equilibrium between a solid and its ions, in a saturated solution, as dynamic OR • Explains the meaning of a static equilibrium OR • Explains the meaning of a dynamic equilibrium	1

Sample answer
The equilibrium between a solid and its ions, in a saturated solution, is dynamic. In a dynamic equilibrium, externally it appears as if there is no change (macroscopic properties remain the same), but at a particle level the reaction is going at equal rates in opposite directions. Some of all of the reactants and products remain in the container.

A static equilibrium is one in which there is no movement and no change is occurring. In a physical environment, there is no net force on an object. In a chemical process, the reaction has stopped.

If you have a reaction that can occur in only one direction, you can reach static equilibrium once you have used up the limiting reagent. When an acid (HCl) is added to a flask containing an excess of solid metal (Mg), the reaction stops when, for example, all the acid has reacted, even though some particles of magnesium remain.

Question 25 (8 marks)
25 (a) (2 marks)
Outcomes Assessed: CH12–5, CH12–13
Targeted Performance Bands: 2-4

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

Sample answer

Water. H_2O
$pK_a = -\log(K_a) = -\log(1.0 \times 10^{-14}) = 14.00$ (2 dp not marked) (same rule for s.f. in pK_a calculations as in pH; see below)

---

25 (b) (2 marks)
Outcomes Assessed: CH12–5, CH12–13
Targeted Performance Bands: 3-6

Criteria	Marks
Calculates the pH (2dp not marked)	2
Shows some correct working and reasoning	1

Sample answer

$HCN\ (aq) + H_2O\ (l) \rightleftharpoons CN^-\ (aq) + H_3O^+\ (aq)$

$$K_a\ HCN = \frac{[CN^-]\,[H_3O^+]}{[HCN]} = 6.2 \times 10^{-10}$$

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

$$K_a\ HCN = \frac{[x]\,[x]}{[0.10 - x]} = 6.2 \times 10^{-10}$$

Since x will be small by comparison with 0.10

Hence $[x]^2 = 6.2 \times 10^{-10} \times 0.10 = 6.2 \times 10^{-11}$

$[H_3O^+] = \sqrt{(6.2 \times 10^{-11})} = 7.87 \times 10^{-6}$ mol/L

Hence $pH = -\log_{10}(7.87 \times 10^{-6}) = 5.10$ (2 s.f.)

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25 (c) (3 marks)
Outcomes Assessed: CH12–5, CH12–7, CH12–13
Targeted Performance Bands: 3-6

25 (c) (i)

Criteria	Mark
Explains why this mixture acts as a buffer Either outlining that it resists change in pH when an acid or a base is added OR Explaining that roughly equimolar amounts of a weak acid and its conjugate base were used.	1

Sample Answer

A buffer solution is one which will maintain an almost constant pH, even if small quantities of strong acid or base are added to it. As long as there are close to equal moles of equal concentration solutions making up the buffer mixture, and the acid and base are both only moderately strong as acids and bases, the solution will stay at close to the pH value.

25 (c) (ii)

Criteria	Marks
Calculates the pH to 2 d.p.	3
Determines the $[H_3O^+]$ in the buffer	2
Determines the concentrations of each species immediately after mixing	1

Sample answer

$HCN\ (aq) + H_2O\ (l) \rightleftharpoons CN^-\ (aq) + H_3O^+\ (aq)$

$$K_a\ HCN = \frac{[CN^-]\,[H_3O^+]}{[HCN]} = 6.2 \times 10^{-10}$$

Initial [HCN] = 0.10 mol/L
Initial $[CN^-]$ = 0.10 mol/L
On mixing, the volume is doubled.
So the concentration of each is halved.
After mixing, [HCN] = 0.050 mol/L
After mixing, $[CN^-]$ = 0.050 mol/L

Let x mol/L HCN ionise at equilibrium.

At equilibrium
[HCN] = (0.050 – x) mol/L
$[CN^-]$ = (0.050 + x) mol/L
$[H_3O^+]$ = x mol/L

$$K_a\ HCN = \frac{[CN^-]\,[H_3O^+]}{[HCN]} = 6.2 \times 10^{-10} = \frac{(0.05 + x)\,(x)}{(0.05 - x)}$$

Since x is small by comparison with 0.05 mol/L

$[H_3O^+] = x = 6.2 \times 10^{-10}$ mol/L

pH = 9.21

Question 26 (8 marks)
26 (a) (1 mark)
Outcomes Assessed: CH12–4, CH12-7, CH12–12
Targeted Performance Bands: 2-3

Criteria	Mark
• Writes the correct equilibrium constant expression	1

Sample answer

$$K_{eq} = \frac{[CoCl_4^{2-}]}{[Co(H_2O)_6^{2+}]\,[Cl^-]^4}$$

---

26 (b) (2 marks)
Outcomes Assessed: CH12–4, CH12–7, CH12–12
Targeted Performance Bands: 3-5

Criteria	Marks
• Predicts the colour change from light blue to pink in terms of the concentrations of ions using Le Chatelier's Principle	2
• Predicts the colour change from light blue to pink but without correct explanation	1

Sample answer

The dilution of the sample will have greater impact on the reactants than products (5 ions on LHS vs 1 on RHS). By Le Chatelier's Principle, the equilibrium position will shift to counteract the change. This means the equilibrium will move to the left to produce more pink hydrated cobalt ions and colourless chloride ions. The solution will become more pink (less blue).

26 (c) (3 marks)

Outcomes Assessed: CH12–6, CH12-7, CH12–12
Targeted Performance Bands: 3-5

i)

Criteria	Mark
• Correct answer (showing correct states)	1

Sample answer
Ag^+ *(aq)* + Cl^- *(aq)* → AgCl *(s)*

ii)

Criteria	Marks
• Predicts that the equilibrium will move to the left as chloride ions are removed by formation of a precipitate AND • Uses collision theory to explain the change	2
• Predicts that the equilibrium will move to the left as chloride ions are removed by formation of a precipitate	1

Sample answer

The $AgNO_3$ solid will dissolve in the equilibrium mixture. The equilibrium will move to the left as the silver ions react with the chloride ions to form a white precipitate of silver chloride.

The backward reaction can continue but the rate of the forward reaction is reduced by the removal of the chloride ions from the equilibrium mixture. Hence the blue $CoCl_4^{2-}$ will react to form more pink $Co(H_2O)_6^{2+}$ ions. A new equilibrium is reached which contains a smaller proportion of blue ions and a larger proportion of pink ions.

(Note: The equilibrium will be not be destroyed as only 0.06 mol Ag^+ has been added but there are 0.10 moles of Cl^- in 20 mL of the equilibrium mixture.)

Ag^+ *(aq)* + Cl^- *(aq)* → AgCl *(s)*

26 (d) (2 marks)

Outcomes Assessed: CH12–5, CH12–7, CH12–12
Targeted Performance Bands: 3-5

Criteria	Marks
• Explains (using collision theory or Le Chatelier's Principle) that the reaction is endothermic as the equilibrium shifts to the right when the temperature increases	2
• States that the forward reaction to form blue $CoCl_4^{2-}$ is endothermic	1

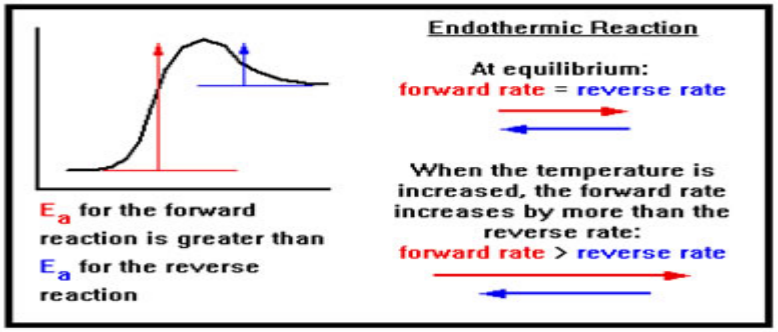
Sample answer
In a reaction at equilibrium, an increase in temperature will always increase the rate of the endothermic reaction more than the rate of the exothermic reaction.

An increase in temperature will always favour the reaction that cools the reaction vessel (the endothermic reaction).

With an increase in temperature, a greater proportion of the particles will have energy equal to or greater that the activation energy. This means the rate of the endothermic forward reaction will temporarily increase more than the rate of the exothermic reaction.

The equilibrium will shift to the right and more blue $CoCl_4^{2-}$ will form. A new equilibrium with a greater proportion of $CoCl_4^{2-}$ than previously will be established at the higher temperature.

For teachers:



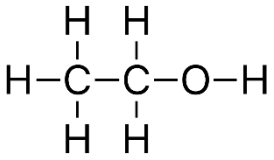
Question 27 (7 marks)

27 (a) (4 marks)

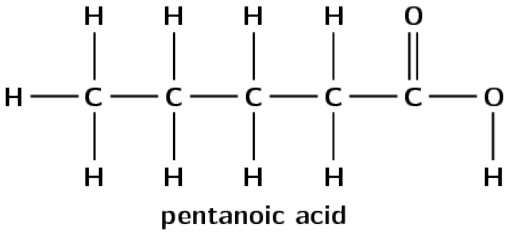
Outcomes Assessed: CH12–7, CH12–14
Targeted Performance Bands: 3-4

Criteria	Marks
• Names AND draws structural formulae for ethanol and pentanoic acid	3
• Draws 2 correct structural formulae and correctly names 1 of these OR • Draws 1 correct structural formula and gives 2 correct names	2
• Draws 2 correct formulae OR 2 correct names OR • 1 correct formula AND 1 correct name	1

Sample answer



ethanol



pentanoic acid

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

Criteria	Marks
• Identifies ethanol as Spectrum B and identifies pentanoic acid as Spectrum C AND • Justifies the selections using data from the spectra	2
• Identifies ethanol OR pentanoic acid OR • Justifies the selection using data from the spectra OR • Identifies BOTH ethanol AND pentanoic acid	1

Sample answer
Reactant: ethanol, Spectrum B

The O-H absorption band at 3300 cm^{-1} (3200–3600 cm^{-1}) corresponds to an –OH in an alcohol and there is no C=O absorption band.

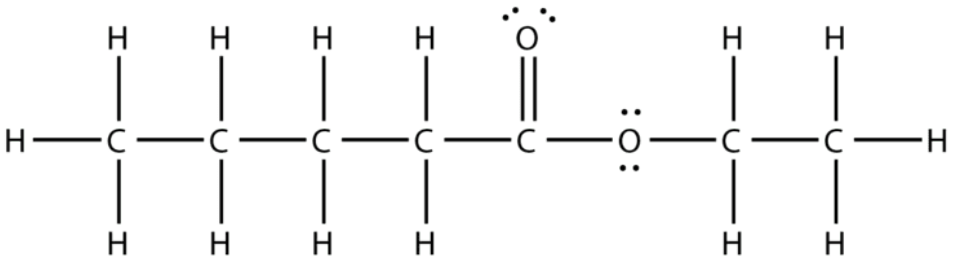
Reactant: pentanoic acid, Spectrum C

The O-H (very broad) absorption band at 3000 cm^{-1} (2500-3500 cm^{-1}) indicates an –OH group in an acid; the C=O absorption band at 1700 cm^{-1} (1680–1740 cm^{-1}) indicates a C=O in an acid.

27 (c) (1 mark)
Outcomes Assessed: CH12–7, CH12–14
Targeted Performance Bands: 2-3

Criteria	Mark
• Draws the correct formula for ethyl pentanoate	1

Sample answer



(electron pairs not required)

Question 28 (5 marks)
28 (a) (2 marks)
Outcomes Assessed: H4, H8
Targeted Performance Bands: 3-5

Criteria	Marks
Justification of TWO appropriate methods	2
Justification of ONE appropriate method	1

Sample answer
$2NO\ (g) + O_2\ (g) \rightleftharpoons 2NO_2\ (g)$ $\quad \Delta H$ = -ve

By Le Chatelier's Principle, the equilibrium can be forced to the right (and thus increase the yield of nitrogen dioxide) by
(i) using an excess of oxygen - reaction will shift to the RHS to use up the added oxygen thus increasing yield of nitrogen dioxide,
or by carrying out the reaction (ii) at high pressure - # moles on the RHS is less than that on the LHS (3:2) - so rxn will shift to RHS since there are less moles to reduce the effect in increased pressure.
or (iii) at low temperature - rxn is exothermic - so lowering the temp will force the rxn to shift to the RHS to make more 'heat' and so increase yield of nitrogen dioxide.
In each case, the equilibrium shifts to the right to compensate for the change in the equilibrium conditions.

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28 (b) (4 marks)
Outcomes Assessed: H10
Targeted Performance Bands: 2-4

Criteria	Marks
Correct equilibrium constant expression AND • Correct calculation of the equilibrium concentrations of all 3 gases and final answer	3
Correct equilibrium constant expression OR Correct calculation of the equilibrium concentrations of all 3 gases	2
Any valid piece of relevant information	1

Sample answer (or draw up an ICE table)

		Equilibrium concentration
Initially		
[NO *(g)*]	= 2.5/10 = 0.25 mol/L	0.5/10 = 0.05 mol/L
[O_2 *(g)*]	= 1.2/10 = 0.12 mol/L	0.2/10 = 0.02 mol/L
[NO_2 *(g)*]	= 0 mol/L	2.0/10 = 0.20 mol/L

$$K = \frac{[NO_2\,(g)]^2}{[O_2\,(g)]\,[NO\,(g)]^2} = \frac{(0.20)^2}{(0.02)\,(0.05)^2} = \frac{0.0400}{(0.02)\,(0.0025)} = 800$$

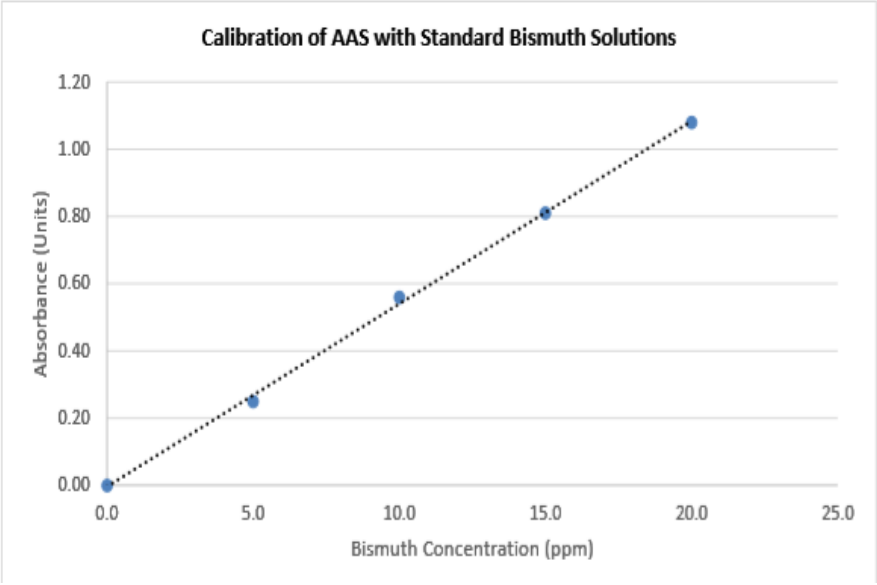
Question 29 (5 marks)
29 (a) (3 marks)
Outcomes Assessed: CH12–4, CH12–7, CH12–15
Targeted Performance Bands: 2-4

Criteria	Marks

• Draws a calibration line on the grid, including ALL of
  • regular and suitable scales on both axes
  • correct plotting of points
  • line of best fit with points above and below the trend line
	2

• Draws a calibration line on the grid, including TWO of the above	1

Sample answer



29 (b) (1 mark)
Outcomes Assessed: CH12–7, CH12–15
Targeted Performance Bands: 2-3

Criteria	Mark
• Correct answer	1

Sample answer
9.0 – 9.9 ppm

29 (c) (2 marks)

Outcomes Assessed: CH12-7, CH12-15

Targeted Performance Bands: 3-5

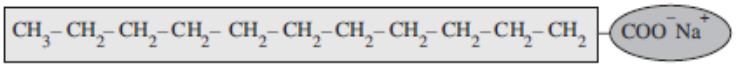
Criteria	Marks
• Explains that AAS uses a unique frequency light source, which only bismuth will absorb AND • Explains that other trace elements have different energy levels to those of bismuth, so electrons cannot be excited by frequencies emitted by the bismuth lamp	2
• Identifies that AAS uses a unique frequency light source, which only bismuth will absorb	1

Sample answer

AAS uses a light energy source of a particular "fingerprint" frequency, unique to bismuth. Hence other trace elements in the sample, which will not absorb at the same frequency, are not detected and will not interfere with the analysis for bismuth.

Question 30 (4 marks)

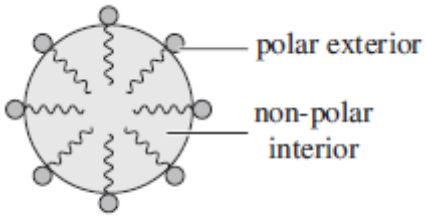
The sodium salts of long chain fatty acids consist of two parts: a non-polar hydrophobic 'tail' consisting of fatty acids; and a polar, hydrophilic, charged 'head' consisting of the sodium salt of the alkanoic acid, as shown below.



non-polar tail polar head

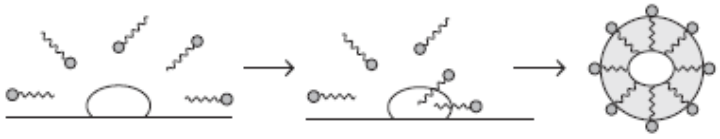
simplified representation

A micelle forms when sodium salts assemble so that the long hydrophobic tails all point inwards and the polar heads all sit on the outside of the micelle.



micelle

The hydrophobic tails embed themselves in the grease. The hydrophilic heads are attracted to the water and lift the grease off the dirty dishes to reform a micelle that then remains suspended in water.



Note: While the question requires a diagram of only a single micelle, diagrams of micelle formation or action such as those above may help to develop high-quality responses.

Mod 7 Reactions of Organic Acids and Bases CH12– 6, CH12–7, CH12–13

Band 4

- Provides a detailed explanation of the surfactant properties of the sodium salts of long chained fatty acids.

AND

- Includes a detailed diagram of a micelle 3–4

- Provides an explanation of the surfactant properties of the sodium salts of long chain fatty acids.

AND

- Includes a diagram of a micelle 2

- Provides some relevant information….1

Question 31 (6 marks)

31 (a) (2 marks)

Outcomes Assessed: CH12–7, CH12–14, CH12–15

Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies ALL of **A**, **B**, **C** and **D**	2
• Identifies TWO or THREE of **A**, **B**, **C** and **D**	1

Sample answer

A = acid
B = alcohol
C = alkene
D = alkane

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31 (b) (2 marks)

Outcomes Assessed: CH12–7, CH12–14, CH12–15

Targeted Performance Bands: 2-4

Criteria	Marks
• Writes the correct balanced equation for the reaction of ethanoic acid with sodium carbonate to produce carbon dioxide, water and sodium ethanoate (eqn without Na but showing ions ok) - states not marked	2
• Writes an equation for the reaction of ethanoic acid but product(s) not correct OR • Correct structures of ethanoic acid OR sodium ethanoate plus $CO_2 + H_2O$ OR • If A is not an acid then correct structure drawn plus $CO_2 + H_2O$ OR • Correct equation with correct formulas of reactants and products but the equation is not balanced	1

Sample answer

$2CH_3COOH\ (aq) + Na_2CO_3\ (aq) \rightarrow CO_2\ (g) + H_2O\ (l) + 2CH_3COONa\ (aq)$

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31 (c) (2 marks)

Outcomes Assessed: CH12–7, CH12–14, CH12–15

Targeted Performance Bands: 2-4

Criteria	Marks
• Writes the correct equation for the reaction of ethene and bromine (states not marked) AND • Identifies 1,2-dibromoethane as the product (or 1,1-dibromoethane)	2
• Writes the correct equation for the reaction of ethene and bromine OR • Identifies 1,2-dibromoethane as the product (or 1,1-dibromoethane) OR • incorrect product but correct name (eg 1-bromoethane)	1

Sample answer

$CH_2CH_2\ (g) + Br_2\ (aq) \rightarrow CH_2BrCH_2Br\ (l)$

1,2-dibromoethane is formed. (or 1,1-dibromoethane)