



2020 |

HSC Trial Chemistry

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours.
- Write using black pen.
- Draw diagrams using pencil.
- For questions in Section II, show all relevant working in questions involving calculations.
- NESA approved calculators may be used.
- Write your NESA number in the spaces provided.

Total marks: 100

Section I – 20 marks (pages 3 – 10)

- Attempt questions 1 – 20.
- Allow about 35 minutes for this section.
- Answer on multiple choice answer page 11

Section II – 80 marks (pages 11 – 30)

- Attempt questions 21 – 37
- Allow about 2 hours and 25 minutes for this section.

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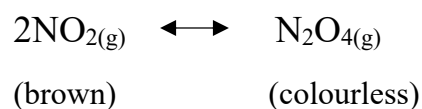
Section I – Multiple Choice (20 marks)

Attempt Questions 1 – 20

Allow about 35 minutes for this section

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

1. Consider the reaction:



$\text{NO}_{2(g)}$ was introduced into a closed syringe which was then capped and left for several minutes. The plunger was then pulled out so as to increase the volume in the syringe.

Which observation and explanation is correct?

	Observation	Explanation
(A)	Colour fades	Equilibrium shifts to side with more moles of gas
(B)	Colour increases	Equilibrium shifts to side with more moles of gas
(C)	Colour increases	Equilibrium shifts to side with fewer moles of gas
(D)	Colour fades	Equilibrium shifts to side with fewer moles of gas

2. Consider the following data:

Solution	Initial pH	Final pH
1	1.0	4.0
2	2.0	6.0
3	6.0	3.0
4	9.0	3.0

In which solution has the $[\text{H}_3\text{O}^+]$ has increased 1000 times?

- (A) 1
(B) 2
(C) 3
(D) 4

3. The correct equilibrium expression for K_{eq} for the following reaction is:

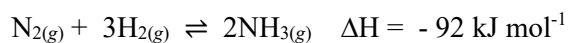
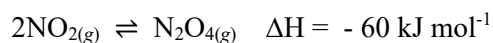


- (A) $[\text{H}_2\text{O}_{(g)}][\text{SO}_{2(g)}]$
- (B) $\frac{[\text{H}_2\text{O}_{(g)}][\text{SO}_{2(g)}]}{[\text{H}_2\text{S}_{(g)}][\text{O}_{2(g)}]}$
- (C) $\frac{[\text{H}_2\text{S}_{(g)}]^2[\text{O}_{2(g)}]^3}{[\text{H}_2\text{O}_{(g)}]^2[\text{SO}_{2(g)}]^2}$
- (D) $\frac{[\text{H}_2\text{O}_{(g)}]^2[\text{SO}_{2(g)}]^2}{[\text{H}_2\text{S}_{(g)}]^2[\text{O}_{2(g)}]^3}$

4. Which alternative is the best explanation of the action of detergents?

- (A) The intermolecular bonding capabilities of a detergent molecule are due to the hydrogen atoms within the molecule.
- (B) The length of a detergent molecule enables its overall polarity.
- (C) The hydrophilic nature of a detergent molecule allows it to break up grease and fats.
- (D) One end of the detergent molecule is polar while the other end is non-polar.

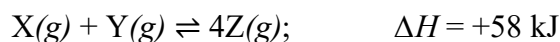
5. Consider the two reactions at equilibrium shown below:



Which action will drive BOTH reactions to form more product?

- A. Reducing the overall pressure
- B. Increasing the reaction temperature
- C. Increasing the volume of the reaction vessel
- D. Removing the product from the reaction vessel

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



Under which set of conditions would the highest yield of $Z(g)$ be obtained?

	<i>Temperature ($^{\circ}\text{C}$)</i>	<i>Pressure (kPa)</i>
(A)	50	100
(B)	50	200
(C)	300	100
(D)	300	200

7. Arrhenius' theory of acids does not explain the acid-base behaviour of which reaction?

- (A) $\text{HCl}_{(g)} + \text{NH}_{3(g)} \rightarrow \text{NH}_4\text{Cl}_{(s)}$
(B) $\text{CH}_3\text{COOH}_{(aq)} \rightarrow \text{CH}_3\text{COO}^{-}_{(aq)} + \text{H}^{+}_{(aq)}$
(C) $2\text{HCl}_{(aq)} + \text{CaCO}_{3(s)} \rightarrow \text{CaCl}_{2(aq)} + \text{CO}_{2(g)} + \text{H}_2\text{O}_{(l)}$
(D) $\text{HF}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{F}^{-}_{(aq)} + \text{H}_3\text{O}^{+}_{(aq)}$

8. Which of the following is the conjugate base of NH_2^{-1} ?

- (A) NH_3
(B) NH^{4+}
(C) NH^{-2}
(D) N^{-3}

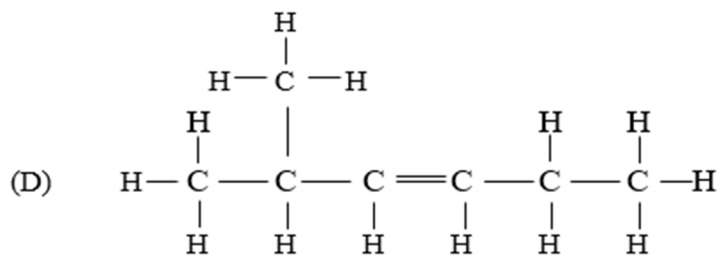
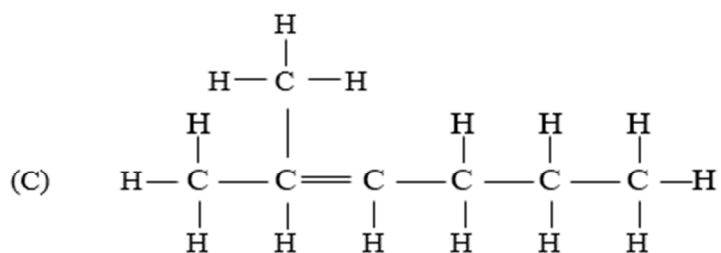
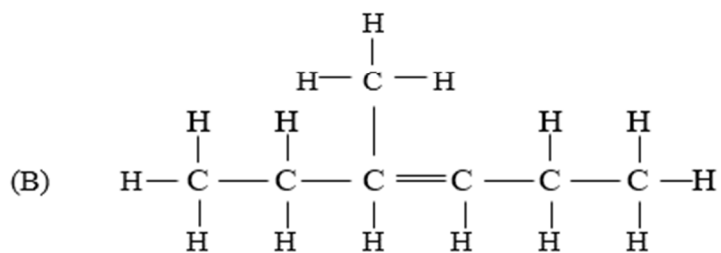
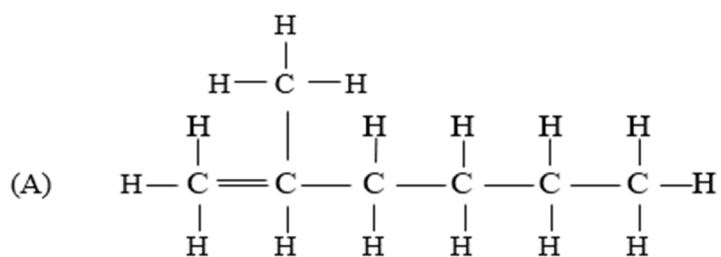
9. A beaker contains 200 mL of 0.40 M HNO_3 . The correct calculation for pH is?

- (A) $\text{pH} = -\log (0.40 \text{ M})$
(B) $\text{pH} = -\log (10^{-14} / 0.40 \text{ M})$
(C) $\text{pH} = -\log (0.40 \text{ M} \times 0.200 \text{ L})$
(D) $\text{PH} = -\log (0.40 \text{ M} / 0.200 \text{ L})$

10. How many isomers exist for C_5H_{12} ?

- (A) 1
- (B) 2
- (C) 3
- (D) 4

11. The structural formula representing 2-methyl-3-hexene is:



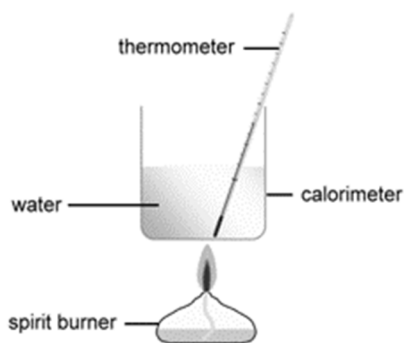
12. Which concentration of an HCl solution would have the same pH as a solution of 0.50 mol L^{-1} acetic acid?

The K_a of acetic acid is 1.8×10^{-5} .

- (A) 0.090 mol L^{-1}
- (B) 0.030 mol L^{-1}
- (C) $0.0090 \text{ mol L}^{-1}$
- (D) $0.0030 \text{ mol L}^{-1}$

13. A student conducted an investigation to find the enthalpy of combustion of propanol.

Apparatus was set up as shown, and relevant data collected and recorded.



Data table

Volume of water used	300 mL
Initial temperature of water	18.9 °C
Initial mass of spirit burner with propanol	187.5 g
Final temperature of water	28.5 °C
Final mass of spirit burner with propanol left	183.4 g

The student made the assumption that 50% of the heat of the combusting propanol was absorbed by the water.

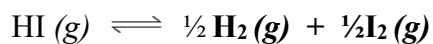
The student calculated that the actual enthalpy of combustion of propanol is:

- (A) 353 kJ mol^{-1}
- (B) 176 kJ mol^{-1}
- (C) 120 kJ mol^{-1}
- (D) 88 kJ mol^{-1}

14. The equilibrium constant for the reaction below has an equilibrium constant K_I .



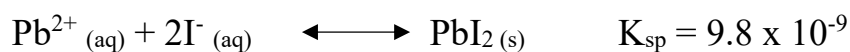
At the same conditions of temperature and pressure, what is the equilibrium constant for the reaction:



- (A) 0.00629
(B) 0.0793
(C) 2.6
(D) 79.5
15. The K_{sp} of $\text{Ca}(\text{OH})_2$ at 25°C is 5.02×10^{-6} .

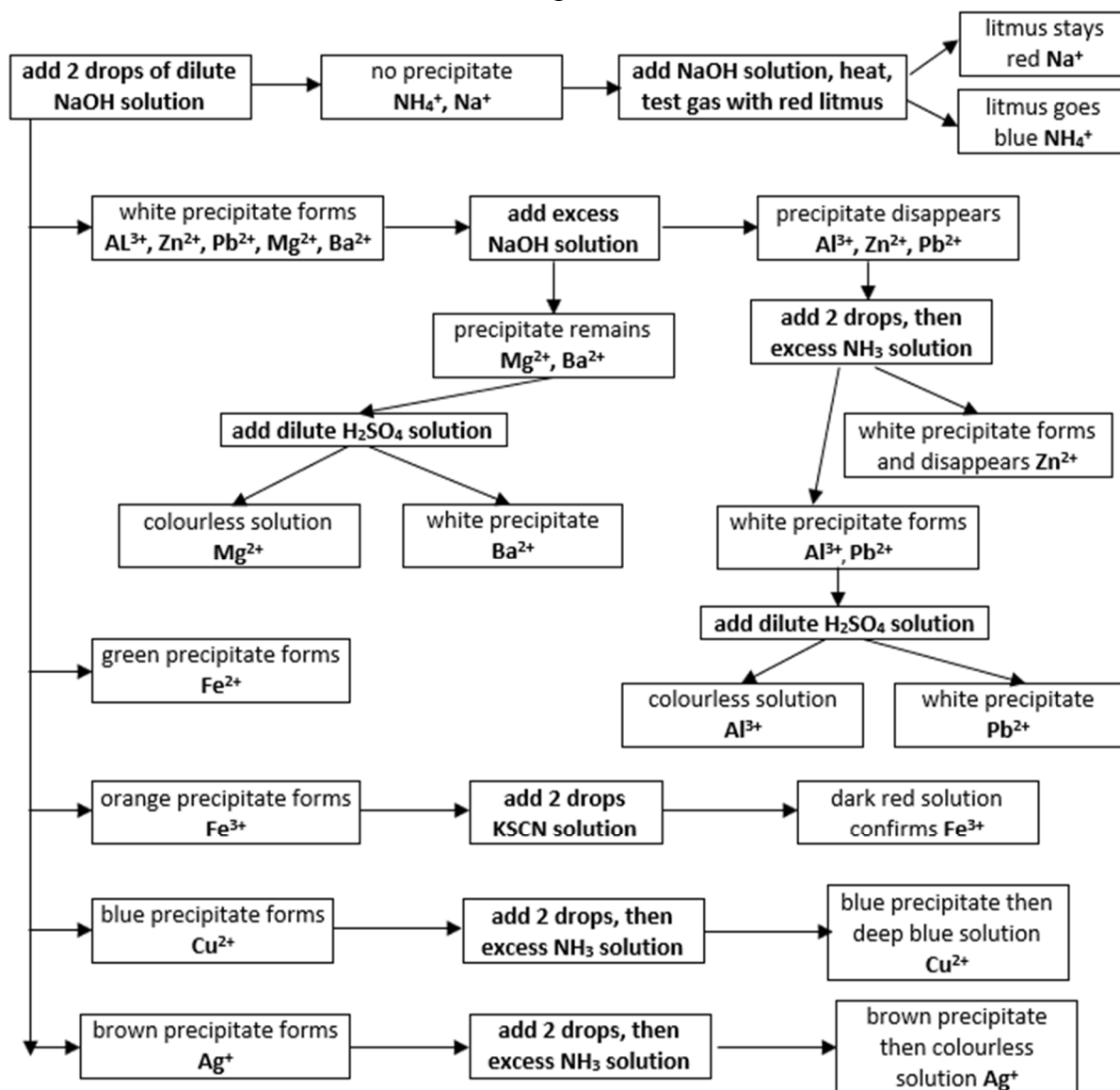
What is the molar solubility of calcium hydroxide at this temperature?

- (A) 1.71×10^{-2}
(B) 1.08×10^{-2}
(C) 2.24×10^{-3}
(D) 5.06×10^{-4}
16. In which case will a precipitate form, given the following information?



	$[\text{Pb}^{2+}]$	$[\text{I}^-]$
(A)	4.5×10^{-6}	4.4×10^{-2}
(B)	4.5×10^{-6}	4.9×10^{-2}
(C)	2.8×10^{-5}	3.7×10^{-4}
(D)	2.8×10^{-5}	4.2×10^{-4}

17. Consider the flowchart and the following information:



- I When 2 drops of NaOH solution was added to a sample, a white precipitate was formed.
- II After excess NaOH solution was added the precipitate disappeared.
- III When 2 drops, then excess NH_3 solution was added, a white precipitate appeared.
- IV After dilute H_2SO_4 solution was added, the result was a colourless solution.

The ion present in the solution is:

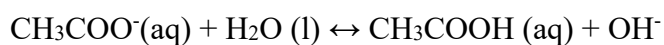
- (A) Pb^{2+}
- (B) Al^{3+}
- (C) Mg^{2+}
- (D) Zn^{2+}

18. A sample of Teflon, polytetrafluorethene, was found to have a molecular mass of $1.9 \times 10^4 \text{ g mol}^{-1}$.

On average, how many monomer units are there in the polymer?

- (A) 190
- (B) 186
- (C) 258
- (D) 212

19. When solid sodium ethanoate is dissolved in water, the following reaction takes place.



Given the pK_a of ethanoic acid is 4.76 at 25°C , what is the pH of a 0.420M solution of sodium ethanoate?

- (A) 2.6
- (B) 4.8
- (C) 9.2
- (D) 11.4

20. 3.50 g of ethanol was refluxed with 5.75 g of methanoic acid. The product was extracted and found to weigh 4.23 g.

The percentage yield in this process is closest to:

- (A) 34%
- (B) 46%
- (C) 74%
- (D) 75%

End of Section 1



NESA number:

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HSC Course

Chemistry 2020

Trial Examination

Answer Part A on this sheet

Select the alternative A,B,C or D that best answers the question.
Fill in the response oval completely
Eg: $2 + 4 =$

(A) 2 (B) 6 (C) 8 (D) 9

A ☐ B ☒ C ☐ D ☐

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

A ☒ B ☒ C ☐ D ☐

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

A ☒ B ☒ C ☐ D ☐
Correct

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

Outcome												
Knowledge and Understanding	1-11	21	22	23	24	27	28	29	31	35		TOTAL
	/11	/4	/3	/3	/4	/5	/4	/3	/4	/9		/50
Working Scientifically	12-20	25	26	30	32	33	34					
	/9	/10	/6	/10	/3	/6	/6					/50
TOTAL												/100

Section II Answer Booklet

80 Marks

Allow about 2 hours and 25 minutes for this part

- 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 questions you are answering.

Question 21 (4 marks)

Marks

Describe the relationship between collision theory and reaction rate, and how equilibrium reactions are affected by these concepts.

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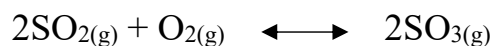
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Question 22 (3 marks)**Marks**

Given that for the reaction:



the value of $K_{\text{eq}} = 6.5$ at a certain temperature T.

In a sealed container, initial concentrations were as follows:

$$[\text{SO}_2] = 0.47 \text{ mol L}^{-1}$$

$$[\text{O}_2] = 0.62 \text{ mol L}^{-1}$$

$$[\text{SO}_3] = 0.21 \text{ mol L}^{-1}$$

By performing appropriate calculations, explain how the reaction will proceed to equilibrium.

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Question 23 (3 marks)

Given the K_{sp} of $\text{Mn}(\text{OH})_2 = 2.0 \times 10^{-13}$, calculate the pH of a saturated solution of manganese hydroxide.

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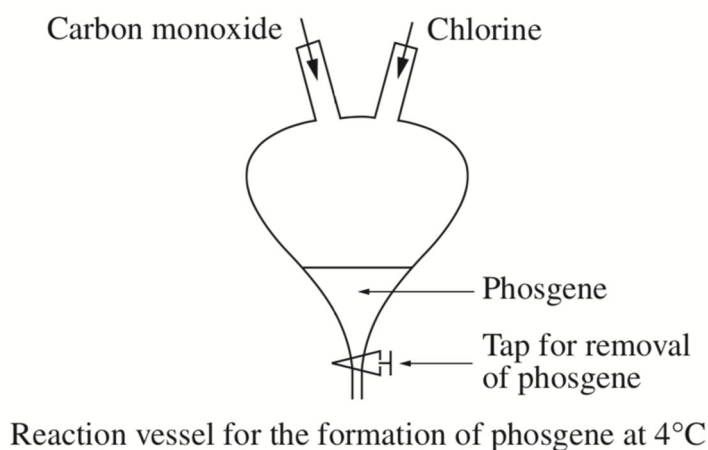
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Question 24 (4 marks)

Marks

Carbonyl chloride, COCl_2 , is a colourless, poisonous gas that is also known as phosgene. It is needed for the production of insecticides, polyurethane plastics and polycarbonate. It is produced from the exothermic equilibrium reaction of carbon monoxide gas and chlorine gas. When the reaction vessel is cooled below 8°C the phosgene is a liquid.



- (a) Write a balanced equation for the formation of phosgene.

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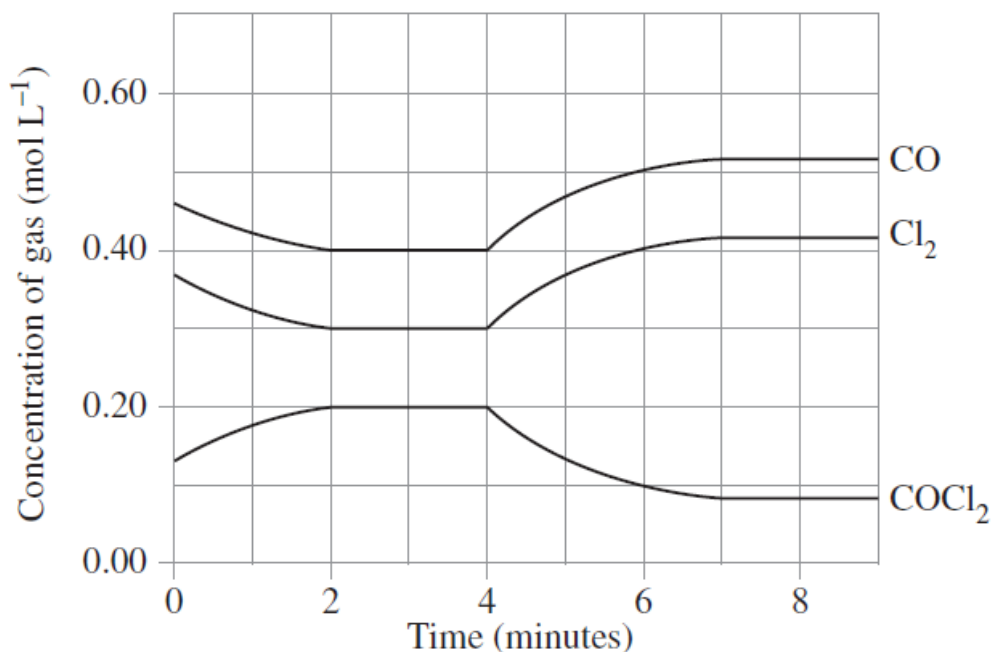
- (b) Explain how industry could maximise the production of phosgene.

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Question 25 (10 marks)

A mixture of carbon monoxide, chlorine and phosgene (COCl_2) gases was placed in a closed container. The concentrations of the gases were monitored over time.



- (a) At what time does the system first reach equilibrium? Justify your answer. 2

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- (b) At four minutes, the temperature of the container was increased. Explain, with reference to the graph, whether the decomposition of COCl_2 into CO and Cl_2 is exothermic or endothermic. 3

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Question 25 Continued on next page

Question 25 Continued

- (c) Use the data from the graph to calculate the equilibrium constant for the reaction at a time $t = 3 \text{ min}$ **3**

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- (d) Will the equilibrium constant at $t = 8 \text{ min}$ be the same as at $t = 3 \text{ min}$?

Explain your response

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Question 26 (6 marks)

Marks

50.0 mL of a solution of 0.300 mol L⁻¹ NaOH was added to a 50.0 mL solution of 0.250 mol L⁻¹ HNO₃ in an insulated cup.

The initial temperature of both solutions was 21.0 °C. The final temperature of the resulting solution was 22.5 °C.

- (a) Calculate the experimental heat of neutralisation from these results.

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- (b) Given that the generally accepted value for the molar heat of neutralisation is 58 kJ mol⁻¹, determine the percentage error in the above calculation.

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- (c) Suggest ONE change to the experimental design used above that would improve the accuracy of the investigation.

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Question 27 (5 marks)

- (a) With the use of chemical equations, show the amphoteric nature of the hydrogen sulphate ion. 2

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- (b) State the definition of conjugate pairs and identify ONE conjugate pair in your response in part (a). 3

Describe the acidic/basic nature of each species in the pair.

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Question 28 (4 marks)**Marks**

Using an appropriate chemical equation to support your answer, explain why an equimolar solution of $\text{H}_2\text{CO}_3/\text{NaHCO}_3$ acts as a buffer, whereas H_2CO_3 (aq) alone does not.

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Question 29 (3 marks)

Propanoic acid is a weak acid that is used as preservative in some packaged foods.

The pH of a 0.200 mol/L aqueous solution of propanoic acid is 2.78.

(a) Write an equation which shows the ionisation of this weak acid in aqueous solution.

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(b) Calculate the degree of ionisation of propanoic acid molecules. Express your answer as a percentage.

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Question 30 (10 marks)**Marks**

The table below shows the change in electrical conductivity during the titration of 20.00 mL of 0.100 mol L⁻¹ Hydrochloric acid (HCl) solution against Sodium Hydroxide solution (NaOH).

	Volume of NaOH added (mL)	Conductivity of the solution: Siemens per metre (S/m)
1.	0.00	187.5
2.	2.00	182.5
3.	4.00	177.5
4.	6.00	172.5
5.	8.00	167.5
6.	10.00	162.5
7.	12.00	157.5
8.	14.00	152.5
9.	16.00	152.5
10.	18.00	157.5
11.	20.00	162.5
12.	22.00	167.5
13.	24.00	172.5

- (a) Using the graph paper (on the next page) plot the conductivity of the solution against the volume of NaOH added.

4**Question 30 continues**

Question 30 (continued)

This image shows a full page of blank graph paper. The grid consists of small, equal-sized squares formed by thin black lines. There are no margins, text, or other markings on the page.

Question 30 (continued)

Question 30 continued

- (b) What volume of NaOH solution is required to reach the equivalence point? 1

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- (c) Calculate the concentration of the sodium hydroxide solution. 2

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- (d) Using your graph explain why the conductivity of the solution changes as the sodium hydroxide solution is added during the titration? 3

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NESA number:

Question 31 (4 marks)

Marks

In an addition reaction, hydrogen chloride is reacted with cyclohexene.

- (a) Name the product formed and draw its structural formula.

2

- (b) Name and draw the structural formula for all possible products of the reaction between chlorine gas and propene.

2

Question 32 (3 marks)

Draw and name three isomers with the molecular formula C_4H_8O

3

Question 33 (6 marks)

Marks

Polymers are important substances and are found in many applications in our society.

- (a) Polyhydroxybutyrate is a polymer formed from the polymerisation of 3-hydroxy butanoic acid.

2

Draw a monomer of polyhydroxybutyrate.

- (b) Use a diagram to show how two of these monomers can join to begin to form the polymer.

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- (c) Name another kind of polymer other than condensation polymers and outline how they differ from condensation polymers.

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Question 34 (6 marks)

Marks

Outline an investigation that you could do to distinguish between ethanol and 2- methyl-2 propanol. Include a suitable method with diagram of the expected results. Describe and explain your results using structural formula in your equations.

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Question 35 (9 marks)**Marks**

The properties of three compounds, **X**, **Y** and **Z** are given in the table.

<i>Compound</i>	<i>Carboxylic acid</i>	<i>Primary Amine</i>	<i>Amide</i>
<i>Example</i>	CH ₃ COOH	CH ₃ CH ₂ CH ₂ NH ₂	CH ₃ CONH ₂
<i>Name</i>	X	Y	Z
<i>Molecular weight (g mol⁻¹)</i>	60.052	59.112	59.068
<i>Boiling Point (°C)</i>	118	48	221
<i>pK_a</i>	4.756	10.71	0.63

(a) Name the three compounds shown:

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X

Y

Z

(b) Compare the structure and properties of these three compounds

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Section II extra writing space.

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

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