CRANBROOK SCHOOL

1	2	5

Centre Number

Student Number

2021

TRIAL EXAMINATION

Chemistry

General Instructions

- Assessment Task 4 – Weighting 15%
- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- The HSC formula sheet, data sheet and Periodic Table should have been printed out
- A piece of graph paper should have been printed out

Total marks: 100

Section I – 20 marks (pages 2-9)

- Attempt Questions 1-20
- Allow about 35 minutes for this section
- Write answers on the separate multiple choice answer sheet

Section II – 80 marks (pages 11-28)

- Attempt Questions 21-36
- Allow about 2 hours and 25 minutes for this section
- Write answers in the exam booklets provided

Section I – 20 marks

Attempt Questions 1–20

Allow about 35 minutes for this part

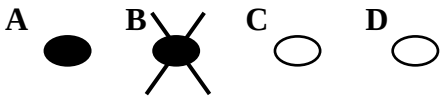
Use the multiple-choice answer sheet for Questions 1–20.

Use the multiple-choice answer sheet

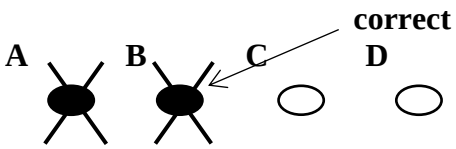
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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

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



If you 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 as follows.



Section I – 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. What is the solubility product expression for tin (II) hydroxide, $Sn(OH)_2$?

A. $[Sn^{2+}][OH^-]$

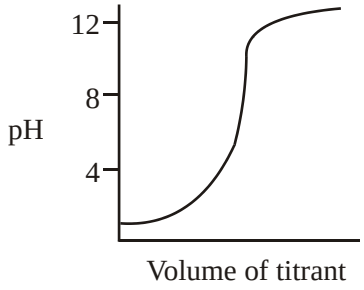
B. $[Sn^{2+}]^2[OH^-]$

C. $[Sn^{2+}][OH^-]^2$

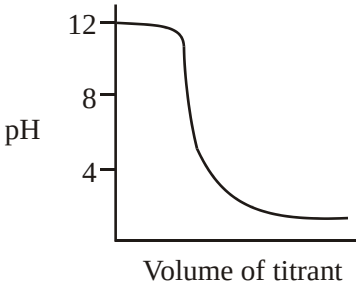
D. $[Sn^{2+}][OH^-]^3$

2. Which curve is produced by the titration of a 0.1 mol L^{-1} weak base with a 0.1 mol L^{-1} strong acid?

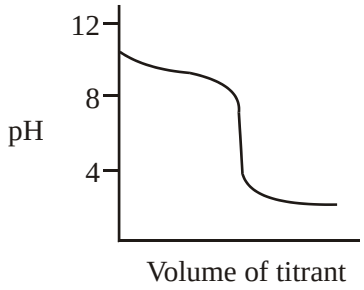
A.



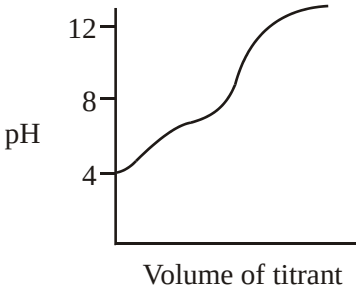
B.



C.



D.



3. Which **one** of the following species is amphiprotic?

A. CH_3COOH

B. NO_3^-

C. $H_2PO_4^-$

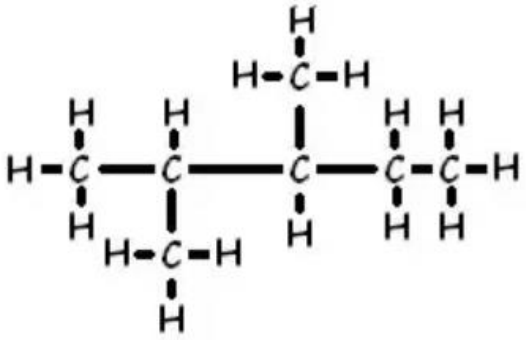
D. OH^-

4. Which of the following substances are structural isomers of each other?

   I. $CH_3(CH_2)_3CH_3$
   II. $(CH_3)_2CHCH_3$
   III. $CH_3CH(CH_3)CH_2CH_3$

   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III

5. What is the name of the compound shown below?



   A. Heptane
   B. 2-methylhexane
   C. 2,3-dimethylpentane
   D. 2-methyl-3-ethylbutane

6. Which is a conjugate acid-base pair in the following reaction?

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

   A. HNO_3 and H_2SO_4
   B. HNO_3 and $H_2NO_3^+$
   C. HNO_3 and HSO_4^-
   D. $H_2NO_3^+$ and HSO_4^-

7. The equilibrium between nitrogen dioxide, NO_2, and dinitrogen tetroxide, N_2O_4, is shown below.

$$2NO_{2\,(g)} \rightleftharpoons N_2O_{4\,(g)} \quad K_{eq} = 0.01$$

What happens when the volume of a mixture at equilibrium is decreased at a constant temperature?

I. The value of K_{eq} increases
II. More N_2O_4 is formed
III. The ratio of $\frac{[NO_2]}{[N_2O_4]}$ decreases

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

8. The reaction below represents the Haber process for the industrial production of ammonia.

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

The optimum conditions of temperature and pressure are chosen as a compromise between those that favour a high yield of ammonia and those that favour a fast rate of production. Economic considerations are also important.

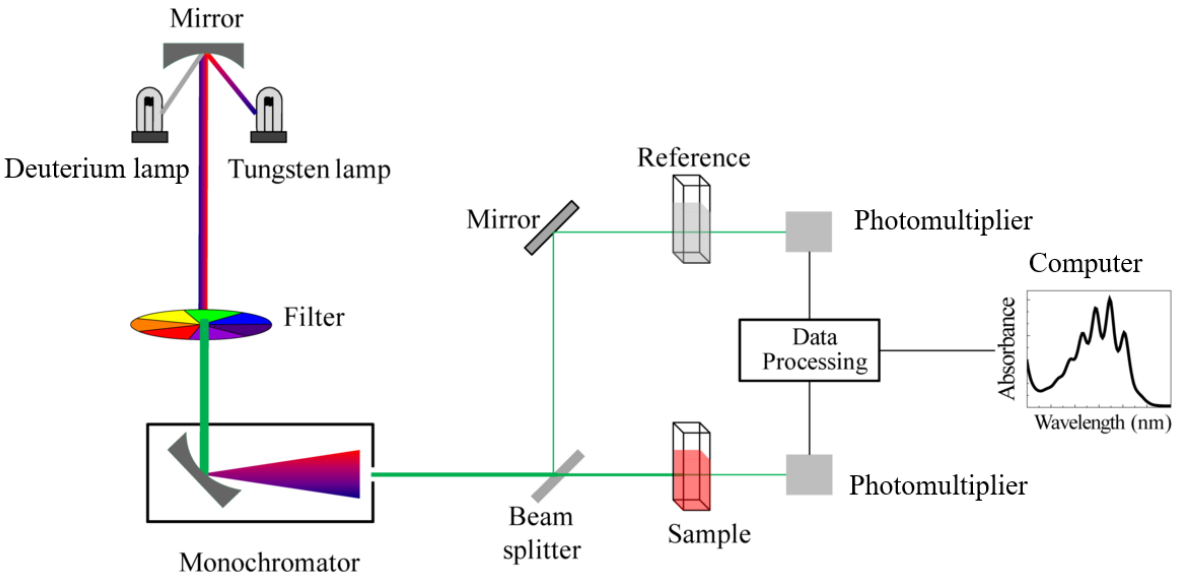
Which of the following statements is correct?

A. A higher temperature would ensure higher yield and a faster rate.
B. A lower pressure would ensure a higher yield at a lower cost.
C. A lower temperature would ensure a higher yield and a faster rate.
D. A higher pressure would ensure a higher yield at a higher cost.

9. A flame test can be used to distinguish between

A. Calcium chloride and barium chloride
B. Ethanoic acid and propanoic acid
C. Any two metals
D. Calcium chloride and calcium nitrate

10. The diagram below represents which analytical instrument?



A. Atomic Absorption Spectrometer

B. Colourimeter

C. UV-visible spectrophotometer

D. Spectroscope

11. The value of the equilibrium constant for the reaction

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

is 0.25 at 440°C. What would the value of the equilibrium constant be for the following reaction at the same temperature?

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

A. 0.25

B. 0.50

C. 2.0

D. 4.0

12. What is the pH of a 0.045 mol L^{-1} barium hydroxide solution?

    A. 1.046

    B. 1.35

    C. 12.65

    D. 12.95

13. Which of the following answers contains the correct missing statements (in the location of the question marks) for the paragraph below, in order?

    "When we mix together, from separate sources, the ions of a slightly soluble ionic salt, the salt will precipitate if Q_{sp} ___?___ K_{sp}, and will continue to precipitate until Q_{sp} ___?___ K_{sp}."

    A. is greater than; equals

    B. is less than; is greater than

    C. is less than; equals

    D. equals; is greater than

14. What is the organic product of the reaction between $CH_3CH_2NH_2$ and CH_3CH_2COOH?

    A. $CH_3CH_2NHCOCH_2CH_3$

    B. $CH_3CH_2CH_2NHCOCH_3$

    C. $CH_3CH_2NHCOCH_3$

    D. $CH_3NHCOCH_3$

15. Which structure could represent a repeating unit of a polymer formed from propene?

    A. $\vdash CH_2–CH(CH_3)\dashv$

    B. $\vdash CH_2–CH_2–CH_2\dashv$

    C. $\vdash CH(CH_3)–CH(CH_3)\dashv$

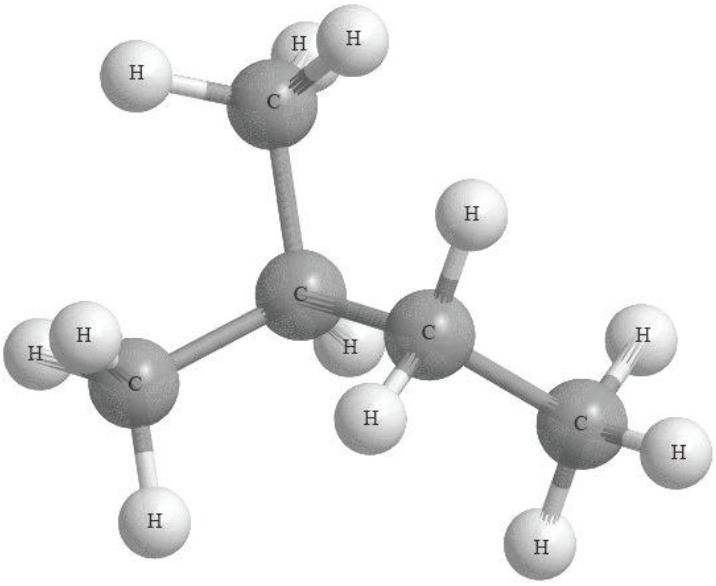
    D. $\vdash CH_2–CH_2\dashv$

16. What is the correct order of reaction types in the following sequence?

$$C_3H_7Br \xrightarrow{\textbf{I}} C_3H_7OH \xrightarrow{\textbf{II}} C_2H_5COOH \xrightarrow{\textbf{III}} C_2H_5COOC_2H_5$$

	I	**II**	**III**
A.	substitution	oxidation	condensation
B.	addition	substitution	condensation
C.	oxidation	substitution	condensation
D.	substitution	oxidation	substitution

17. The following is a three-dimensional representation of an organic molecule.



Which statement is correct?

A. The correct IUPAC name of the molecule is 2-methylpentane.
B. All the bond angles will be approximately 90°.
C. One isomer of this molecule is pentane.
D. The boiling point of this compound would be higher than that of pentane.

18. Separate 20.0 mL solutions of a weak acid and a strong acid of the same concentration are titrated with NaOH solution. Which will be the same for these two titrations?

    I. Initial pH
    II. pH at equivalence point
    III. Volume of NaOH required to reach the equivalence point

    A. I only

    B. III only

    C. I and II only

    D. II and III only

19. A 25.00 mL solution of 0.500 mol L^{-1} sulfuric acid was added to a 25.00 mL solution of 0.500 mol L^{-1} sodium hydroxide.

    What is the pH of the resulting mixture?

    A. 1.903

    B. 2.204

    C. 7.000

    D. 11.796

20. Consider the following solubility data for various chromates at 25°C.

Chromate	K_{sp}
Ag_2CrO_4	9.0×10^{-12}
$BaCrO_4$	2.0×10^{-10}
$PbCrO_4$	1.8×10^{-14}

    Which of the following chromate compounds is the **most** soluble in water at 25°C per mole?

    A. Ag_2CrO_4

    B. $BaCrO_4$

    C. $PbCrO_4$

    D. There is insufficient data to determine this

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2021

TRIAL

EXAMINATION

Chemistry

Section II Answer Booklet

80 marks
Attempt Questions 21-36
Allow about 2 hours and 25 minutes for this section

- Answer the questions in the exam booklets provided. The spaces you can see on screen provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Clearly indicate which question you are answering in your exam booklets.

Question 21 (3 marks)

In your course you conducted a first-hand investigation to analyse the reversibility of the chemical reaction between iron (III) nitrate and potassium thiocyanate.

The equation for this reversible reaction is shown below:

$$Fe(NO_3)_{3\,(aq)} + 3KSCN_{\,(aq)} \rightleftharpoons 3KNO_{3\,(aq)} + Fe(SCN)_{3\,(aq)}$$

Initially there was 0.250 mol of iron (III) nitrate and 0.500 mol of potassium thiocyanate in a solution of 100.00 mL (there were no products initially). The solution was left to reach equilibrium where there was 0.100 mol of iron (III) thiocyanate in the 100.00 mL solution.

Calculate K for this reaction at this temperature

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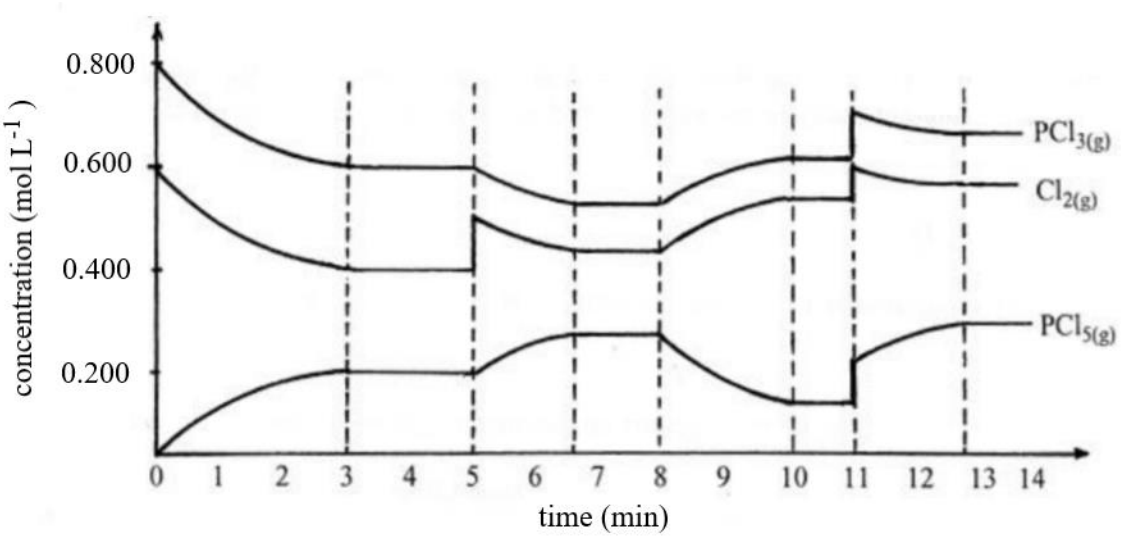
Question 22 (9 marks)

The graph below shows the concentration of three substances involved in a reversible reaction over 14 minutes. The equation for this reaction is shown below:

$$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)} \quad \Delta H = -92.5 \text{ kJ mol}^{-1}$$



a) Outline what is occurring between t = 3min and t= 5 min. **2**

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b) Calculate the equilibrium constant, using the data at time t = 4 min. **2**

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Question 22 continues on the next page

c) Identify the stress that occurred at t = 8 min and justify your answer. **3**

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d) Explain your answer to part c), in terms of collision theory. **2**

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Question 23 (8 marks)

a) Calculate the molar solubility of barium hydroxide at 25^{o}C. **2**

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b) The barium hydroxide is added to a 0.150 mol L^{-1} sodium hydroxide solution at 25^{o}C. Calculate the molar solubility of barium hydroxide in this solution. **2**

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c) Account for any difference in your answers to part a) and part b) above. **2**

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d) The reaction of lead (II) nitrate and potassium iodide is a favourite of teachers to demonstrate precipitation reactions, producing the bright yellow precipitate, lead (II) iodide. If lead (II) iodide is insoluble in this reaction, explain why it appears on the HSC Chemistry Data Sheet with a solubility constant of 9.8 x 10^{-9}. **2**

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Question 24 (4 marks)

Acid theories have changed over time. Explain why theories change, referring to two specific examples of acid theories.

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Question 25 (6 marks)

A biologist is worried about the effect of pollution on the eggs of a species of bird they are studying. They are concerned that the eggshells are too thin and the chicks are hatching too early reducing their chance of survival. They enlist the help of a chemist to determine the percentage by mass of calcium carbonate in the eggshells.

The chemist followed the following steps:

1. The shell was dried in a drying oven for 30 minutes to remove any water
2. The shell was crushed using a mortar and pestle into a powder
3. The crushed eggshell was weighed on an electronic balance
4. A 25.00 mL solution of 1.00 mol L^{-1} hydrochloric acid was added to the eggshell until a clear solution was formed.
5. To this 25.00 mL flask, 3 drops of phenolphthalein was added
6. A standardised solution of 0.500 mol L^{-1} sodium hydroxide was added to a 50.00 mL burette
7. The sodium hydroxide was titrated from the burette into the flask
8. The average titre value for their sodium hydroxide was recorded

Data collected by the chemist:
Mass of eggshell : 1.25 g
Average titre value: 12.55 mL

a) Calculate the percentage by mass of calcium carbonate in the eggshell. **4**

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b) The normal healthy range of calcium carbonate in the eggshell of this species in 85-93%. Explain if the biologist was correct to be concerned. **2**

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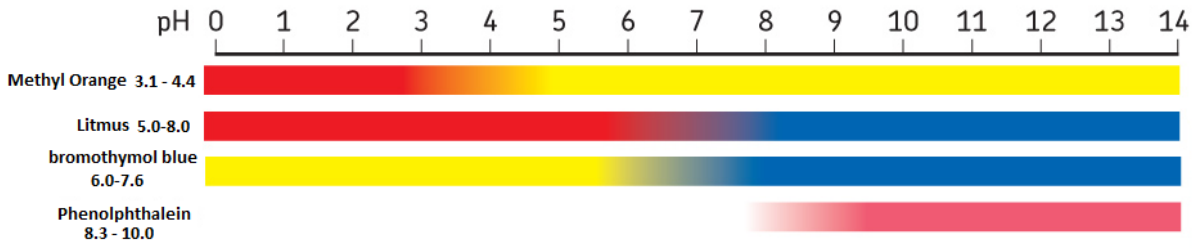
Question 26 (6 marks)

Indicators change colour at different pH values. The diagram below shows some indicators, their end points and their colours at different pH values.



a) Explain how indicators work. **3**

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b) A clear solution turns yellow with methyl orange, blue with litmus, green with bromothymol blue and colourless in phenolphthalein. Identify the pH of the solution as a range of values. Justify your answer. **3**

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Question 27 (4 marks)

Carbonic acid is a weak acid (pK_a = 6.377 at 298K).

a) Calculate the pH of carbonic acid at 298K. **2**

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b) The carbonic acid – bicarbonate buffer system is important in natural systems. Calculate the pH of this buffer solution made from 0.400 mol L^{-1} carbonic acid and 0.300 mol L^{-1} sodium carbonate. **2**

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Question 28 (7 marks)

The boiling points of some compounds from three different types of organic molecules (alkenes, amines and carboxylic acids) are shown below.

Name	mass (g/mol)	bp (°C)	Name	mass (g/mol)	bp (°C)	Name	mass (g/mol)	bp (°C)
						Methanoic acid	46	101
			Ethylamine	45.1	17	Ethanoic acid	60.1	118
Propene	42.1	-47	1-propylamine	59.1	49	Propanoic acid	74.1	141
But-1-ene	56.1	-6	1-butylamine	73.1	78	Butanoic acid	88.1	164
Pent-1-ene	70.1	30	1-pentanamine	87.2	104			
Hex-1-ene	84.2	64						

a) Graph the boiling points of these molecules against mass. You should draw three separate lines for the three types of organic molecules. **4**

Use the graph paper you have printed out to answer this question

b) Explain the trends shown in your graph. **3**

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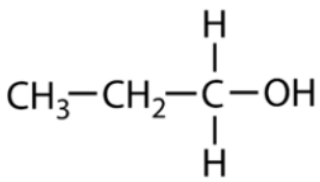
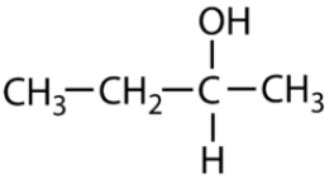
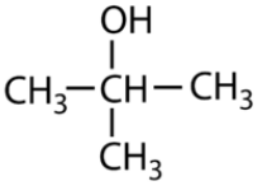
Question 29 (4 marks)

Describe a chemical test that would distinguish between the three alcohol molecules shown below. Include how you would do the tests and the results you would use to determine the identity of each of these molecules.







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Question 30 (6 marks)

Soaps and detergents are very important chemicals in our daily lives

a) Explain how soap cleans dirt off clothes. **3**

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b) Many people in Australia only have access to underground bores which is hard water. It is better for them to use detergent based cleaners rather than soap. Explain why, including a relevant equation. **3**

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Question 31 (3 marks)

Esterification reactions are known for the strong-smelling products that are formed.

Explain what would happen in esterification reactions if:

a) There was no reflux apparatus. **2**

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b) There was no concentrated sulfuric acid added. **1**

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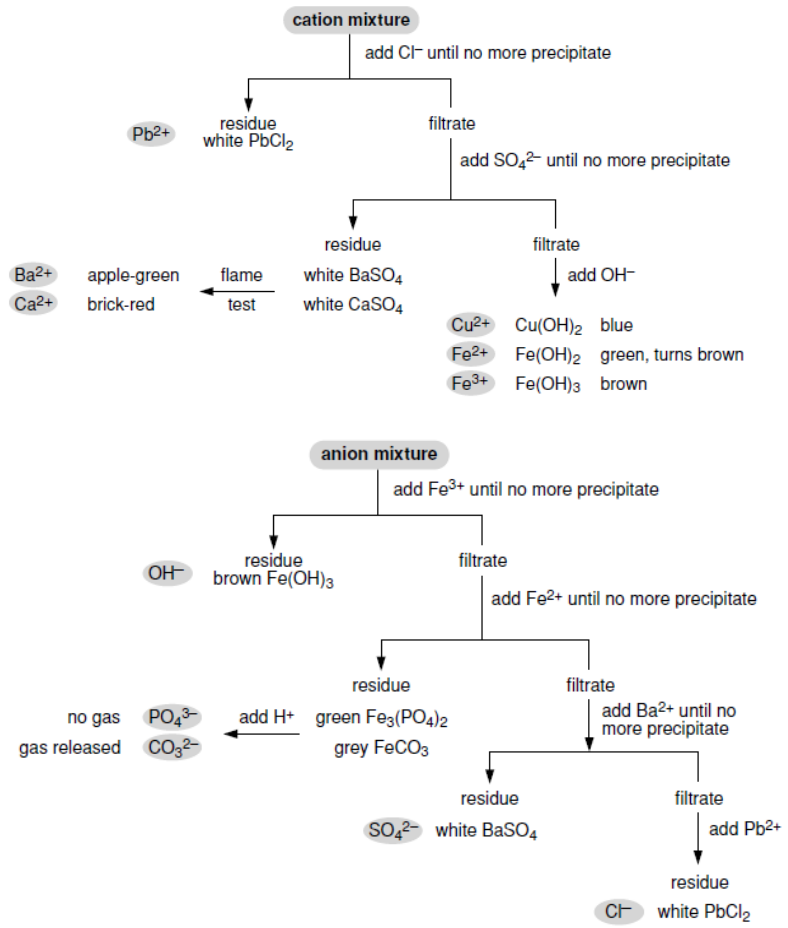
Question 32 (4 marks)

The diagrams below show two flowcharts for identifying unknown cations and ions.



Use the flowcharts and your understanding of ion tests to determine the identity of the salt that caused the following results:

Test 1

Cation solution added	Iron (II)	Iron (III)	Barium
Result	No change	No change	White precipitate

Test 2

Anion solution added	Hydroxide	Chloride	Sulfate
Result	Blue precipitate	No change	No change

a) Identity of ion: …… **1**

b) Write the net ionic equations for the two positive results. **2**

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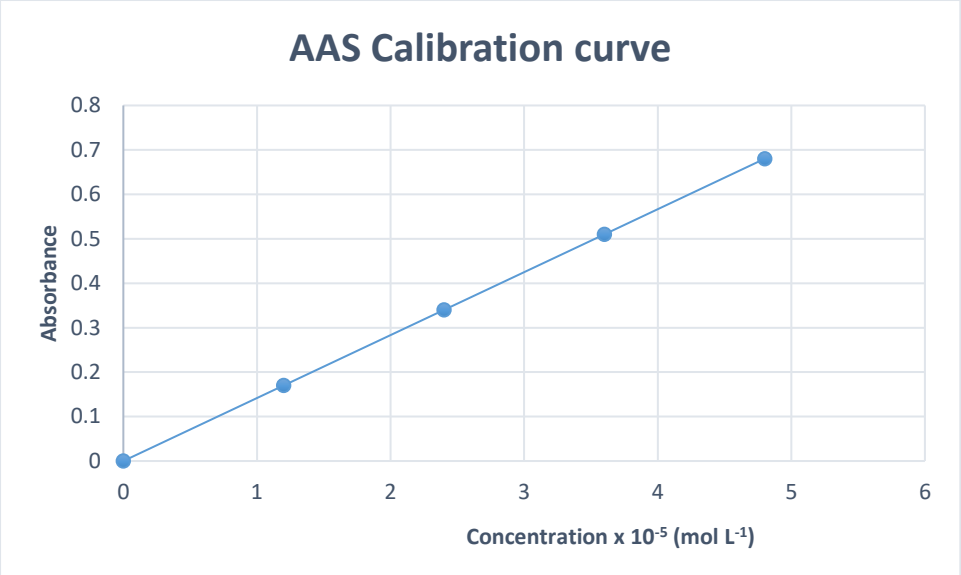
Question 33 (3 marks)

A chemist wanted to determine the amount of lead in a sample of soil using Atomic Absorption Spectroscopy.

The chemist prepared and tested a number of standard solutions of known lead concentration to make the calibration curve below



A 2.00 g sample of the soil was dissolved in acid and then diluted to a total volume of 50.00 mL. The absorbance of the sample was 0.20.

Calculate the concentration of the lead ions in the soil in mg L^{-1}.

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Question 34 (4 marks)

A colourimeter is used to measure the concentration of coloured solutions. Calculate the concentration of a copper sulfate solution in mol L^{-1} given the following data. Note that the unit of light intensity is called the candela (cd)

Light (635 nm) entering the colourimeter (I_o) = 40 cd
Light (635 nm) reaching the detector (I) = 20 cd
Pathlength (l) = 1 cm
Molar absorption coefficient (ε) = 2.81 M^{-1} cm^{-1}

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Question 35 (5 marks)

Sunscreens are labelled with their SPF, which stands for Sun Protection Factor. The SPF number represents the time it takes for your skin to burn compared to the time it would take without applying any sunscreen.

A chemist ran a full spectrum scan using a UV-visible spectrophotometer of sunscreens with three different SPF ratings; SPF 15, SPF 30 and SPF 50. The spectrum produced is shown in Diagram 1. Diagram 2 shows the wavelengths of part of the electromagnetic spectrum.

Diagram 1

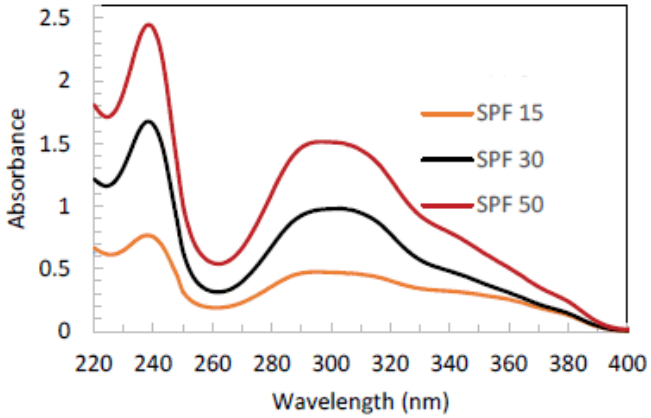
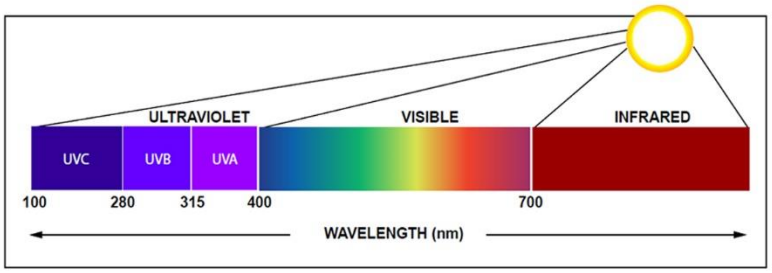


Diagram 2



a) Write a conclusion you can draw from the information in:

i) Diagram 1 only. **1**

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ii) Diagrams 1 and 2 together. **1**

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Question 35 continues on the next page

b) The chemist now wishes to determine the concentration of the SPF chemical in the sunscreen. Outline what he would need to do after running the full spectrum scan above to determine this concentration using the UV-visible spectrophotometer. **3**

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Question 36 (4 marks)

Compare AAS, Colourimetry and UV-visible spectrophotometry.

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End of Trial Examination

2021 Chemistry Trial Exam Marking Guidelines

Test Section	Question	Marks	Outcomes	Targeted Performance Bands	Answer
Section I: Multiple Choice	1	1	CH12-4, 12	3-4	C
	2	1	CH12-13	3-4	C
	3	1	CH12-13	3-4	C
	4	1	CH12-14	3-4	B
	5	1	CH12-14	3-4	C
	6	1	CH12-13	3-4	B
	7	1	CH12-4, 12	3-5	C
	8	1	CH12-12	4-5	D
	9	1	CH12-15	3-5	A
	10	1	CH12-15	4-5	C
	11	1	CH12-4, 12	4-5	D
	12	1	CH12-4, 13	4-5	D
	13	1	CH12-12	4-5	A
	14	1	CH12-14	4-5	A
	15	1	CH12-14	4-5	A
	16	1	CH12-14	4-6	A
	17	1	CH12-14	5-6	C
	18	1	CH12-13	5-6	B
	19	1	CH12-4, 13	5-6	A
	20	1	CH12-12	5-6	A
Section II	21	3	CH12-4, 12	4-6	
	22a	2	CH12-12	3-4	
	22b	2	CH12-4, 12	3-4	
	22c	3	CH12-12	4-5	
	22d	2	CH12-12	5-6	
	23a	2	CH12-4, 12	4-5	
	23b	2	CH12-4, 12	4-6	
	23c	2	CH12-12	4-6	
	23d	2	CH12-12	4-6	
	24	4	CH12-13	3-5	
	25a	4	CH12-4, 13	5-6	
	25b	2	CH12-4, 13	3-4	
	26a	3	CH12-13	4-5	
	26b	3	CH12-13	4-5	
	27a	2	CH12-4, 13	4-5	
	27b	2	CH12-4, 13	4-5	
	28a	4	CH12-4, 14	3-4	
	28b	3	CH12-14	3-5	
	29	4	CH12-14	4-6	
	30a	3	CH12-14	3-4	
	30b	3	CH12-14	4-6	
	31a	2	CH12-14	4-5	
	31b	1	CH12-14	3-4	
	32a	1	CH12-15	3-4	
	32b	2	CH12-15	3-4	
	33	3	CH12-4, 15	4-6	
	34	4	CH12-4, 15	4-5	
	35ai	1	CH12-15	3-4	
	35aii	1	CH12-15	3-4	
	35b	3	CH12-15	4-5	
	36	4	CH12-15	3-5	

Section I – Multiple Choice

Question 1 - C
The Ksp expression derives from the equation:

$Sn(OH)_{2\,(s)} \rightleftharpoons Sn^{2+}{}_{(aq)} + 2OH^{-}{}_{(aq)}$

Only the substances with concentrations are included in the Ksp expression, which are just the products. You take the concentrations to the power of the mole ratio of the balanced equation coefficients.

Question 2 - C
The weak base has a pH above 7 but not too high. The pH at equivalence point will be acidic. The final pH after equivalence will be very low as it is the pH of the strong acid that was added.
Graph A is a strong acid titrated a strong bas
Graph B is a strong base titrated with a strong acid
Graph D is weak acid titrated with a weak base

Question 3 - C
An amphiprotic substance can accept and donate a proton depending on what is reacts with.
$H_2PO_4^-$ can accept a proton from an acid such as hydronium ions (it is acting as a base)

$H_2PO_4^{-}{}_{(aq)} + H_3O^{+}{}_{(aq)} \rightleftharpoons H_3PO_{4\,(aq)} + H_2O_{(l)}$

$H_2PO_4^-$ can donate a proton to a base such as water (it is acting as an acid)

$H_2PO_4^{-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + H_3O^{+}{}_{(aq)}$

Question 4 - B
Structural isomers have the same molecular formula but have different arrangements of their atoms. Both I and III have the molecular formula C_5H_{12}.
I is pentane
III is methylbutane

Question 5 - C
The longest chain can go around corners.
Number side branches to give the smallest possible numbers

Question 6 - B
In this reaction, H_2SO_4 is donating a proton to HNO_3, so H_2SO_4 is the acid. The conjugate base of this acid (what the acid becomes when it loses its proton is HSO_4^-. They are one conjugate pair.
HNO_3 is accepting a proton from H_2SO_4, so HNO_3 is the base. The conjugate acid of this base (what the base becomes when it gains its proton is $H_2NO_3^+$. This is the other conjugate pair. This is the only conjugate pair in the answers.

Question 7 - C
A decrease in volume increases the pressure of this gaseous system. According to LCP, the system opposes this stress and favours the reaction that decreases pressure. This is the reaction that produces less moles of gas, which is the forward reaction. Therefore more N_2O_4 is formed (I).
Increasing $[N_2O_4]$ will cause the ratio of $[NO_2]$ / $[N_2O_4]$ to decrease (bigger number on the denominator). II is not correct. K is only affected by temperature. After the equilibrium is disturbed, the system will eventually return to a state of equilibrium with the same K value.

Question 8 - D
Increasing the pressure is a stress that is opposed in accordance with LCP, favouring the reaction that produces fewer moles of gas, which is the forward reaction. Therefore yield is increased. Increasing pressure is energy intensive, so will mean higher production costs.
A is incorrect, higher temperature reduces yield but does increase rate
B is incorrect, lower pressure reduces yield but does reduce cost
C is incorrect, lower temperature does give a higher yield but at a slower rate.

Question 9 - A
Flame tests can be used to distinguish metals that have a different flame colour. Calcium ions produce a 'brick red' flame. Barium ions produce a yellow-green flame.

Question 10 - C
Key features that show this is a UV-visible spectrophotometer are:

- The two lamps (tungsten for visible light and deuterium for UV)
- The beam splitter sending the particular wavelength of light through the reference sample and testing sample at the same time
- The graph of absorbance v wavelength

Question 11 - D
The K value of the reverse reaction is the reciprocal or $\frac{1}{K}$.

Question 12 - D
The ratio of barium hydroxide to hydroxide ions is 1:2
$Ba(OH)_{2\,(s)}$ à $Ba^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$
0.045 M 0.090M

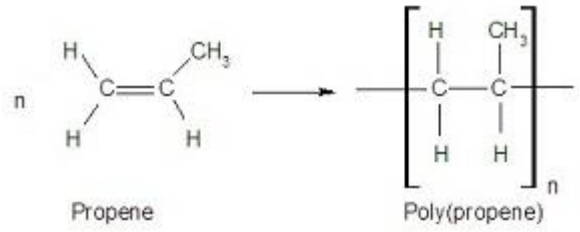
$Kw = [H_3O^+]\,[OH^-] = 10^{-14}$
$[H_3O^+] = 10^{-14} / [OH^-]$
$= 10^{-14} / 0.090$
$= 1.11 \times 10^{-13}$ mol L^{-1}

$pH = -\log [H_3O^+]$
$= -\log 1.11 \times 10^{-13}$
$= 12.95$

Question 13 - A
If $Q_{sp} > K_{sp}$ a precipitate will form. Precipitation will continue until Q=K.

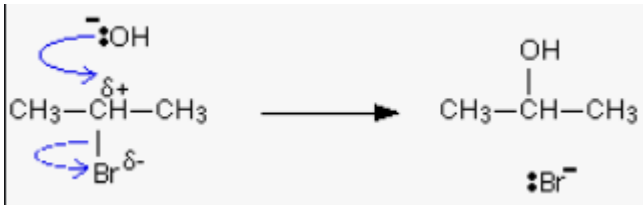
Question 14 - A
This is the condensation reaction between an amine and a carboxylic acid to produce an amide and water. The amine loses an H from the amine group and the carboxylic acid loses an OH from the COOH group. This makes water and the rest of the two molecules join in an amide linkage (NHCO).

Question 15 - A
Best way to draw propene to polymerise is shown. The polymer formed is written in reverse of the diagram below –[CH(CH_3)CH]-



Question 16 - A

Step 1 is converting a haloalkane to an alcohol. This involves heating under reflux with a solution of sodium or potassium hydroxide. The Br is removed and the OH is substituted in its place



Step 2 is converting an alcohol to a carboxylic acid. This occurs through oxidation using acidified dichromate ions in a two-step reaction (forming an aldehyde which is then further oxidised to the carboxylic acid.

Step 3 is the formation of an ester. This involves the carboxylic acid reacting with an alcohol while being heated under reflux. The carboxylic acid and alcohol join with a small molecule of water being lost which is a condensation reaction.

Question 17 - C
The molecule shown is methylbutane. This has the formula C_5H_{12}, so is an isomer of pentane. Therefore answer A is incorrect. Most of the bond angles are 109.5o as the predominant shape is tetrahedral around the carbon atoms, so not answer B. The boiling point of this isomer would be higher than pentane as the side branch makes it harder for molecules to get as close to each other, meaning their intermolecular forces are slightly less.

Question 18 - B
Not I as the pH of the strong acid will be lower at the start than the weak acid
Not II as the pH of the strong acid/strong base at equivalence will be neutral while the pH of the weak acid/strong base at equivalence will be basic.
The volume of NaOH needed to reach equivalence point is about stoichiometry. As you have the same volume and concentration of the strong and weak acids, you have the same number of moles. Therefore the same number of moles of NaOH is needed for neutralisation.

Question 19 – A

The equation for this neutralisation reaction is

$H_2SO_{4\,(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4\,(aq)} + 2H_2O_{(l)}$

$c(H_2SO_4) = 0.500$ mol L^{-1} $v(H_2SO_4) = 0.02500$ L $c = \frac{n}{v}$ $n = cv$ $= 0.500 \times 0.02500$ $= 0.0125$ mol	$c(NaOH) = 0.500$ mol L^{-1} $v(NaOH) = 0.02500$ L $c = \frac{n}{v}$ $n = cv$ $= 0.500 \times 0.02500$ $= 0.0125$ mol

Ratio of H_2SO_4 : NaOH

1 : 2

Option 1 0.0125: 0.0250

Option 2 0.00625: 0.0125

There is not enough NaOH for option 1, so option 2 works and NaOH is the limiting reagent.

Need to find the moles of H_2SO_4 in excess as this will determine the pH.

n(excess H_2SO_4) = 0.0125 – 0.00625

= 0.00625 mol

Sulfuric acid is diprotic

$H_2SO_{4\,(aq)} + 2H_2O_{(l)} \rightleftharpoons SO_4^{2-}{}_{(aq)} + 2H_3O^+_{(aq)}$

$n(H_3O^+) = 2 \times 00625$

$= 0.0125$ mol

$v(H_3O^+) = 50.00$ mL

$= 0.05000$ L

$c = \frac{n}{v}$

$= \frac{0.0125}{0.0500}$

$= 0.250$ mol L-1

$pH = -\log [H_3O^+]$

$= -\log 0.250$

$= 0.602$

Question 20 - A

You need to work out the molar solubility (s) of each chromate to do this question

$Ag_2CrO_{4\,(s)} \rightleftharpoons 2Ag^+_{\,(aq)} + CrO_4^{2-}{}_{(aq)}$

2s s

$Ksp = [Ag^+]^2\,[CrO_4^{2-}]$

$9.0 \times 10^{-12} = (2s)^2 \times (s)$

$= 4s^2 \times s$

$= 4s^3$

$s^3 = 9.0 \times 10^{-12} / 4$

$= 2.25 \times 10^{-12}$

$s = \sqrt[3]{2.25\ x\ 10^{-12}}$

$= 1.31 \times 10^{-4}$ mol L^{-1}

$BaCrO_{4\,(s)} \rightleftharpoons Ag^{2+}_{\,(aq)} + CrO_4^{2-}{}_{(aq)}$

s s

$Ksp = [Ba^{2+}]\,[CrO_4^{2-}]$

$2.0 \times 10^{-10} = (s) \times (s)$

$= s^2$

$s = \sqrt{2.0 \times 10^{-10}}$

$= 1.41 \times 10^{-5}$ mol L^{-1}

$PbCrO_{4\,(s)} \rightleftharpoons Pb^{2+}_{\,(aq)} + CrO_4^{2-}{}_{(aq)}$

s s

$Ksp = [Pb^{2+}]\,[CrO_4^{2-}]$

$1.80 \times 10^{-14} = (s) \times (s)$

$= s^2$

$s = \sqrt{1.80 \times 10^{-14}}$

$= 1.34 \times 10^{-7}$ mol L^{-1}

The largest value for s is silver chromate, so it is the most soluble.

Section II – 80 marks

Question 21 (3 marks)

Criteria	Marks
Calculates concentrations correctly AND correct use of ICE table AND correct equilibrium expression AND correct answer	3
One of the above missing	2
Some correct working	1

Sample answer

Initial concentrations:

$c(Fe(NO_3)_3) = \frac{n}{v}$

$= \frac{0.250}{0.1000}$

$= 2.50 \text{ mol L}^{-1}$

$c(KSCN) = \frac{n}{v}$

$= \frac{0.500}{0.1000}$

$= 5.00 \text{ mol L}^{-1}$

Equilibrium concentrations:

$c(Fe(SCN)_3) = \frac{c}{v}$

$= \frac{0.100}{0.1000}$

$= 1.00 \text{ mol L}^{-1}$

	$Fe(NO_3)_{3\,(aq)}$ +	$3KSCN_{(aq)}$ ⇌	$3KNO_{3\,(aq)}$ +	$Fe(SCN)_{3\,(aq)}$
I	2.50	5.00	0	0
C	-1.00	-3.00	+3.00	+1.00
E	1.50	2.00	3.00	1.00

$K = \frac{[KNO_3]^3\,[Fe(SCN)_3]}{[Fe(NO_3)_3]\,[KSCN]^3}$

$= (3.00)^3 \times (1.00) / (1.50) \times (2.00)^3$

$= (27 \times 1) / (1.50 \times 8)$

$= 27 / 12$

$= 2.25$

Question 22 (9 marks)

22 (a) (2 marks)

Criteria	Marks
Identifies that the system is at equilibrium AND that the rate of the forward reaction is equal to the rate of the reverse reaction	2
One of the above	1

Sample answer
The system is at equilibrium. The forward and reverse reaction are occurring at the same rate.

22 (b) (2 marks)

Correctly states the equilibrium concentrations of the three species and uses the correct equilibrium expression to get the correct answer	2
Mostly correct	1

Sample answer
At t = 4 min

$[PCl_5]$ = 0.200 mol L^{-1}
$[PCl_3]$ = 0.600 mol L^{-1}
$[Cl_2]$ = 0.400 mol L^{-1}

$$K = \frac{[PCl_5]}{[PCl_3][Cl_2]}$$

$$= \frac{0.200}{(0.600) \text{ x } (0.400)}$$
= 0.833 mol^{-1} L

22 (c) (2 marks)

Criteria	Marks
Correctly identifies the stress and gives a detailed explanation of why this was the stress, referring to Le Chatelier's Principle. Cannot state the 'system' is exothermic to get full marks	3
Correctly identifies the stress and gives a partially correct reason for choice	2
Some correct information	1

Sample answer

At t = 8 min the surroundings were heated. You can see from the graph that there is a gradual change in the concentrations of all 3 species, which is indicative of a temperature stress. The stress caused a decrease in the product concentration and an increase in the reactant concentrations, so the equilibrium shifted left. As the forward reaction is exothermic, the stress must have been an increase in temperature, which was opposed in accordance with Le Chatelier's Principle, favouring the reaction that decreased the temperature, which is an endothermic reaction; which is the reverse reaction.

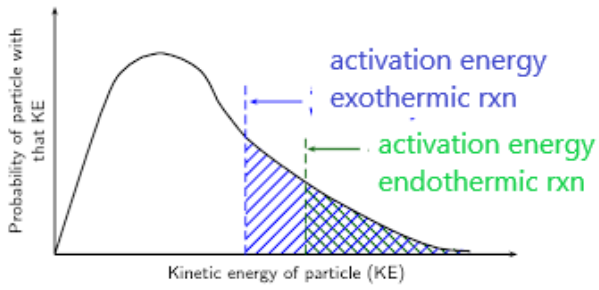
22 (d) (2 marks)

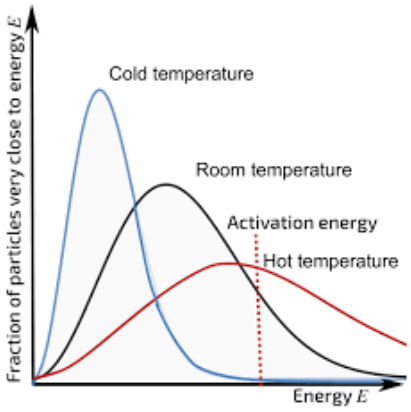
Refers explicitly to collision theory and explains in detail why the rate of the endothermic reaction is more affected by an increase in temperature than the exothermic reaction.	2
Some correct information	1

Sample answer

Collision theory states that for a reaction to occur, the particles must collide, the collisions must occur with sufficient energy and in the correct orientation. The reason that an increase in temperature favours the endothermic reaction is that the activation energy for the endothermic reaction is greater than the exothermic reaction. While an increase in temperature gives all particles more energy increasing their chance of collision and of having effective collisions, an increase in temperature proportionally affects more particles, allowing more particles to reach an energy equal to or greater than the activation energy.

The Maxwell-Boltzmann distribution shows this: The graph on the right shows that as you increase temperature, the number of particles with energy equal to or greater than the activation energy increases. The graph on the right shows that this will have more significance for the endothermic reaction due to the shape of the curve – a greater proportion of particles will now reach activation energy.





Question 23 (8 marks)

23 (a) (2 mark)

Criteria	Marks
Correct answer with detailed working included	2
Mostly correct	1

Sample answer

$Ba(OH)_{2\,(s)} \rightleftharpoons Ba^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$

s 2s

$Ksp = [Ba^{2+}][OH^-]^2$

$2.55 \times 10^{-4} = (s) \times (2s)^2$

$= 4s^3$

$s^3 = 2.55 \times 10^{-4} / 4$

$= 6.375 \times 10^{-5}$

$s = \sqrt[3]{6.375 \times 10^{-5}}$

$= 3.99 \times 10^{-2}$ mol L^{-1}

23 (b) (2 marks)

Criteria	Marks
Correct answer with detailed working included	2
Mostly correct	1

Sample answer

$Ba(OH)_{2\,(s)} \rightleftharpoons Ba^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$

s 0.150 mol L^{-1}

$Ksp = [Ba^{2+}][OH^-]^2$

$2.55 \times 10^{-4} = (s) \times (0.150)^2$

$s = \frac{(2.55 \times 10^{-4})}{0.0225}$

$= 1.13 \times 10^{-2}$ mol L^{-1}

23 (c) (2 marks)

Criteria	Marks
Refers to common ion effect and uses Le Chatelier's Principle to explain the different solubilities	2
Refers to one of the above correctly	1

Sample answer

The difference is called the common ion effect. When the $Ba(OH)_2$ is added to the NaOH solution, the stress is an increase in $[OH^-]$

$Ba(OH)_{2\,(s)} \rightleftharpoons Ba^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$

The stress of an increase in $[OH^-]$ is opposed, favouring the reverse process, forming more solid and therefore the solubility decreases.

23 (d) (2 marks)

Criteria	Marks
Explains that all substances are sparingly soluble or that the Ksp is a measure of how much can dissolve.	2
Partially correct	1

Sample answer

The substances on the data sheet with solubility constants are not completely insoluble. They are said to be sparingly soluble. When you use high concentrations in a precipitation reaction you get the bright yellow precipitate but there is always some lead iodide that dissolves, as per its K_{sp} value.

Question 24 (4 marks)

Criteria	Marks
Outlines what a scientific theory is, why theories change and provides an example to demonstrate this, referring to two acid theories	4
Outlines why theories change and provides an example to demonstrate this, referring to two acid theories.	3
Outlines two theories of acids	2
Some correct information about acid theories	1

Sample answer

A scientific theory is an explanation of observations of the world around and the results of experiments. A theory can only use the current knowledge and understanding and the technologies available. Therefore, theories can change over time, as new things are observed and discovered and understanding of processes increases.

Acid theories have changed over time as new discoveries were made. It was known that acids were substances that were corrosive to skin, tasted sour and could neutralise bases. The first formal theory of an acid was from Lavoisier. He stated that it was oxygen that caused the acidic properties of an acid. A that time, all the known acids (sulfuric, nitric) contained oxygen.

The discovery of the halogens and that when they combined with hydrogen this caused acidic properties, led Davy to change the theory of what an acid was. As acids such as HCl and HF did not contain oxygen, Davy proposed that it was hydrogen that caused the properties of an acid.

Question 25 (6 marks)

25 (a) (4 marks)

Criteria	Marks
Correctly calculates moles of NaOH to find moles of excess HCl, including equation AND Uses this and original amount of HCl added to determine amount of HCl that reacted with eggshell AND uses balanced equation to determine number of moles of CaCO3 that reacted with HCl AND determines the mass of CaCO3 in egg shell and then the % by mass in the egg shell	4
Three steps correct	3
Two steps correct	2
One step correct	1

Sample answer

This is a back titration

Step 1: Calculating the moles of excess HCl that did not react with $CaCO_3$ in eggshell

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

c(NaOH) = 0.500 mol L^{-1}
v(NaOH) = 0.01255 L (avg titre value)

$c = \frac{n}{v}$

n = cv
= 0.500 x 0.01255
= 6.275 x 10^{-3} mol

Ratio NaOH : HCl is 1:1, so the 6.275 x 10^{-3} mol of NaOH reacted with 6.275 x 10^{-3} mol of excess HCl

Step 2: Calculating the moles of HCl that reacted with CaCO3 in eggshell by subtraction (original added – excess found by titration)

Original amount of HCl added to flask with eggshell:

c(HCl) = 1.00 mol L^{-1}
v(HCl) = 0.02500 L

$c = \frac{n}{v}$

n = cv
= 1.00 x 0.02500
= 0.02500 mol

Therefore, amount of HCl that reacted with the eggshell = 0.02500 - 6.275 x 10^{-3}
= 0.018725 mol

Step 3: Calculating the number of moles of CaCO3 in the eggshell

$CaCO_{3\,(s)} + 2HCl_{\,(aq)}$ à $CaCl_{2\,(aq)} + H_2O_{\,(l)} + CO_{2\,(g)}$

Ratio $CaCO_3$: HCl is 1:2, so $n(CaCO_3) = 0.018725/2$
$= 9.3625 \times 10^{-3}$ mol

Step 4: Calculating mass of $CaCO_3$ in eggshell and % by mass

$M(CaCO_3) = 40.08 + 12.01 + (3 \times 16.00)$
$= 100.09$ g mol^{-1}

$n = \frac{m}{M}$
$m = nM$
$= 9.3625 \times 10^{-3} \times 100.09$
$= 0.937$ g

% composition = (mass $CaCO_3$ / mass eggshell) x 100
= (0.937 / 1.25) x 100
= 74.967 %
= 75.0 % (3sf)

25 (b) (2 marks)

Criteria	Marks
Gives correct answer with correct reason	2
Gives correct answer with incorrect reason (no mark for reason without an answer)	1

Sample answer

The biologist is correct to be concerned. The % by mass of $CaCO_3$ of 75% is much lower than the acceptable range of 85-93%.

Question 26 (6 marks)

26 (a) (3 mark)

Criteria	Marks
States that an indicator is a weak acid where the colour of the acid and conjugate base are different, provides an equation, then uses LCP to explain why colour changes in both acid and base	3
States that an indicator is a weak acid where the colour of the acid and conjugate base are different Provides an equation OR uses LCP to explain why colour changes in **both** acid and base	2
Some correct information about how indicators work	1

Sample answer

Indicators are generally weak acids where the acid and its conjugate base are different colours. For the weak acid indicator HIn:

$HIn_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + In^-_{(aq)}$

Colour 1 Colour 2

In acids, the indicator equilibrium is subjected to a stress of increased $[H_3O^+]$. According to Le Chatelier's Principle, the stress is opposed and favours the reverse reaction to reduce $[H_3O^+]$ and Colour 1 is seen.
In bases, the OH^- ions of the base react with the H_3O^+ ions of the indicator. Therefore the stress is a decrease in $[H_3O^+]$. According to Le Chatelier's Principle, the stress is opposed and favours the forward reaction to increase $[H_3O^+]$ and Colour 2 is seen.

26 (b) (3 marks)

Criteria	Marks
Provides the correct pH for the colour shown by each of the four indicators AND Uses this the predict the pH range of the solution	3
Most of the above with the range not quite correct	2
Some correct information	1

Sample answer

The results suggest the following for each indicator:

- Methyl orange – yellow - pH > 4.4
- Litmus – blue – pH > 8.0
- Bromothymol blue – green – pH 6.0 -7.6
- Phenolphthalein – colourless – pH < 8.3

There is some uncertainty around the 7.6 – 8.0 pH between litmus and bromothymol blue but indicator colours can be hard to determine.

Therefore, the best range would be 7.6 – 8.3

Question 27 (4 marks)

27 (a) (2 mark)

Criteria	Marks
Writes correct equation for reaction of carbonic acid with water and calculates Ka and write K expression.	2
Some of the above	1

Sample answer

$H_2CO_{3(aq)} + H_2O_{(l)} \rightleftharpoons HCO_{3^-(aq)} + H_3O^+_{(aq)}$

$K_a = 10^{-pKa}$
$= 10^{-6.377}$
$= 4.198 \times 10^{-7}$

$K_a = \frac{[HCO_3^-][H_3O^+]}{[H_2CO_3]}$

$4.198 \times 10^{-7} = \frac{x^2}{0.400}$

$x^2 = 0.400 \times 4.198 \times 10^{-7}$
$x = \sqrt{1.68 \times 10^{-7}}$
$= 4.10 \times 10^{-4}$ mol L^{-1}

$pH = -\log [H_3O^+]$
$= -\log 4.10 \times 10^{-4}$
$= 3.387$

27 (b) (2 marks)

Criteria	Marks
Use correct values for $[H_2CO_3]$ and $[HCO_3^-]$ to find x AND Correctly calculates pH	2
Partially correct	1

Sample answer

$K_a = \frac{[HCO_3^-][H_3O^+]}{[H_2CO_3]}$

$4.198 \times 10^{-7} = \frac{(0.300)(x)}{0.400}$

$x = \frac{0.400 \times 4.198 \times 10^{-7}}{0.300}$
$= 5.59 \times 10^{-7}$ mol L^{-1}

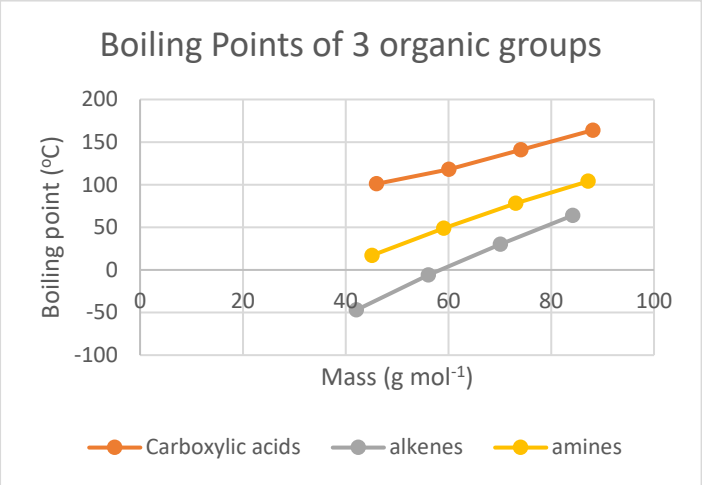
$pH = -\log [H_3O^+]$
$= -\log 5.59 \times 10^{-7}$
$= 6.252$ (3sf)

Question 28 (7 marks)

Question 28 (a) (4 marks)

Criteria	Marks
Graph contains correct axes with labels and units, is to scale, contains a suitable title, points are plotted correctly, a line of best fit is drawn for each group and a key is included	4
Missing one of the above	3
Missing two of the above	2
Some correct components of graph	1

Sample answer



Question 28 (b) (3 marks)

Criteria	Marks
Explains the increasing bp trend in all groups and explains the differences between the three groups in detail referring to intermolecular forces	3
Explains the increasing bp trend in all groups and explains the differences between the three groups briefly or with minor error referring to intermolecular forces OR Explains the differences between the 3 groups in detail referring to intermolecular forces	2
Some correct information about intermolecular forces	1

Sample answer

In all three groups of organic molecules, the boiling point increases with increasing relative molecular mass. This is because as the mass increases there are more electrons and therefore more chance of weak dispersion forces occurring. This increases the attraction between the molecules so more heat is required to separate and boil them.

The boiling points of alkenes are lower than corresponding amines, which are lower than the corresponding carboxylic acids of similar mass. Alkenes are non-polar molecules, so the only intermolecular forces between alkene molecules are weak dispersion forces which require the least heat energy to overcome. In amines, the polar N-H groups give rise to permanent dipoles and hydrogen bonding between amine molecules. Hydrogen bonds are the strongest of the intermolecular forces, requiring more heat energy to break and therefore giving the amines a higher boiling point than the alkenes. In carboxylic acids the polar C=O and O-H covalent bonds create permanent dipoles and hydrogen bonds between molecules. Due to these two polar regions, more hydrogen bonds can form per molecule and more heat energy is required to overcome these hydrogen bonds so carboxylic acids have highest of the boiling points of these three groups

Question 29 (4 marks)

Criteria	Marks
Identifies the three molecules as primary, secondary and tertiary alcohols and describes the chemical tests that would be done to distinguish them, including the results observed	4
Identifies the three molecules as primary, secondary and tertiary alcohols and describes some of the chemical tests that would be done to distinguish them, including the results observed with small error	3
Outlines what primary and secondary alcohols get oxidised to using acidified dichromate, and that tertiary are not oxidised	2
Some correct information about different classes of alcohols	1

Sample answer

The chemical test to use here is oxidation using the acidified dichromate ion. Add 10 mL of the alcohol to a flask and add 5 mL of potassium dichromate and a few drops of concentrate sulfuric acid. Connect to a condenser and heat under reflux.

The first molecule is propan-1-ol. This is a primary alcohol, so gets oxidised to an aldehyde then can be further oxidised under reflux to a carboxylic acid.

The second molecule is butan-2-ol. This is a secondary alcohol, so gets oxidised to a ketone.

To distinguish between the carboxylic acid and ketone, and therefore to identify which of the original molecules is the primary and secondary alcohol, add sodium carbonate. If there are bubbles, this is the carboxylic acid, so this was the primary alcohol originally.

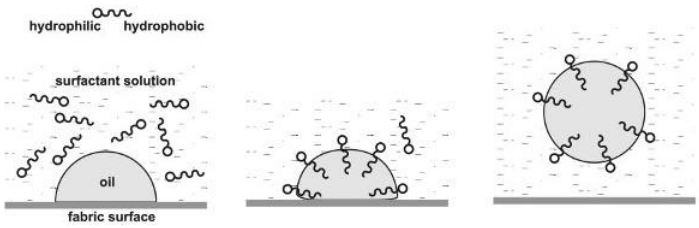
The third molecule is 2-methylpropan-2-ol. This is a tertiary alcohol so will not be oxidised so there will be no colour change in the dichromate.

You know oxidation has occurred when the orange acidified $Cr_2O_7^{2-}$ is reduced to the green Cr^{3+} ion. Only I and II will be oxidised. III will not be oxidised as it is a tertiary alcohol, so there will be no colour change in the dichromate.

Question 30 (6 marks)
Question 30 (a) (3 marks)

Criteria	Marks
Links the structure of soap to how it cleans using detailed chemistry (a well annotated diagram is appropriate here)	3
Links the structure of soap to how it cleans briefly	2
Some correct information	1

Sample answer
The structure of soap enables it to clean surfaces. Dirt molecules are generally non-polar. They are attracted to other non-polar molecules. The long hydrocarbon tail chain of soap is non-polar and hydrophobic. It is attracted to dirt or oil which is also non-polar.
The negatively charged head of soap is polar and hydrophilic, so it is attracted to other polar molecules. Water is polar, so the head part of soap is attracted to water. Anionic, cationic and non-ionic detergents also have polar head regions. Soap forms micelles around the dirt, with the polar heads pointing out. Agitation will wash these micelles away.



Question 30 (b) (3 marks)

Criteria	Marks
Identifies that hard water contains calcium/magnesium ions and that these will form a precipitate with the soap due to reacting with the negative head of the soap. Explains why cationic or non-ionic detergents do not form a precipitate. Writes a balanced equation for the precipitation of soap.	3
Identifies that hard water contains calcium/magnesium ions and that these will form a precipitate with the soap due to reacting with the negative head of the soap. Explains why cationic or non-ionic detergents do not form a precipitate.	2
Identifies that hard water contains calcium/magnesium ions	1

Sample answer
Hard water contains are large amount of calcium and magnesium ions. These ions will form a precipitate when it reacts with soap molecules.

Soap precipitates in hard water when the negatively charged ion forms an insoluble compound with Calcium and/or magnesium ions

For the soap sodium stearate the net ionic equation is:

$2C_{17}H_{35}COO^-_{(aq)} + Mg^{2+}_{(aq)} \rightarrow (C_{17}H_{35}COO)_2Mg_{(s)}$

Cationic detergents have a positive 'head' so they cannot form precipitates with calcium or magnesium as they are both positive. Non-ionic detergents which have no ions will also not form precipitates.

Question 31 (3 marks)

31 (a) (2 mark)

Criteria	Marks
States that esterification would not occur without reflux. Explains that the reaction needs heat and that the volatile reactants would be lost without the reflux apparatus	2
Describes refluxing	1

Sample answer

Esterification will not successfully occur without reflux. Esterification requires heat for the reaction to start and to drive the reaction forward but heating causes the volatile reactants to boil and they would be lost if there was no reflux apparatus and the reaction would not occur.

31 (b) (1 marks)

Criteria	Marks
Outlines the effect of no sulfuric acid on rate	1

Sample answer

If there was no concentrated sulfuric acid added the reaction would be very slow as it is a catalyst that lowers the activation energy

Question 32 (3 marks)

32 (a) (1 mark)

Criteria	Mark
Identifies the salt	1

Sample answer

Copper sulfate

32 (b) (2 marks)

Criteria	Mark
Writes 2 correct equations	2
Writes 1 correct equation	1

Sample answer

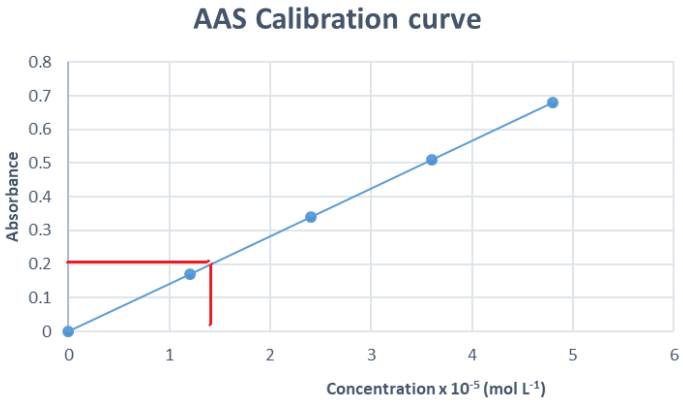
$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$ à $BaSO_{4\,(s)}$

$Cu^{2+}_{(aq)} + 2OH^-_{(aq)}$ à $Cu(OH)_{2\,(s)}$

Question 33 (3 marks)

Criteria	Marks
Uses AAS calibration curve to correctly read concentration and converts this value to concentration of lead ions in 50.0 mL and converts this value to mg L^{-1}	3
	2
Uses AAS calibration curve to correctly read concentration	1

Sample answer



An absorbance of 0.2 is a lead concentration of approximately 1.4 x 10^{-5} mol L^{-1}

2.00 g of soil in 50.0 mL

1.4 x 10^{-5} mol in 1 L

$n(Pb^{2+})$ = 1.4 x 10^{-5} mol
$M(Pb^{2+})$ = 207.2 g mol^{-1}

m = nM
= 1.4 x 10^{-5} x 207.2
= 2.90 x 10^{-3} g
= 2.9 mg L^{-1}

Question 34 (4 marks)

Criteria	Marks
Correctly calculates absorbance from log equation, rearranges equation to calculate concentration, gives answer to 1sf	4
Correctly calculates absorbance from log equation, rearranges equation to calculate concentration	3
Uses absorbance equation with incorrect data to get answer to 1sf	2
Uses absorbance equation with incorrect data to get answer	1

Sample answer

$A = \varepsilon lc$

$A = \log I_o/I$

$= \log 40/20$

$= \log 2$

$= 0.30$

$A = \varepsilon lc$

$c = A/\varepsilon l$
$= 0.30/(2.81 \times 1)$
$= 0.107 \text{ mol } L^{-1}$
$= 0.1 \text{ mol } L^{-1}$ (1sf)

Question 35 (5 marks)

Question 35 (ai) (1 mark)

Criteria	Mark
Makes valid conclusion from Diagram 1	1

Sample answer

The higher the SPF value, the greater the absorbance of UV light

Question 35 (aii) (1 marks)

Criteria	Mark
Makes valid conclusion from both diagrams together	1

Sample answer

The maximum absorbance of 240 nm is UVC.

Question 35 (b) (3 marks)

Criteria	Marks
All steps correctly outlined	3
Most steps correctly outlined	2
Some steps correctly outlined	1

Sample answer

- Select 240 nm as the wavelength to test the sample
- Make three standard solutions of known concentration of SPF factor
- Use the UV-vis spectrophotometer to measure absorbance and make calibration curve
- Place the sunscreen sample in the machine
- Read absorbance and use calibration curve to calculate concentration

Question 36 (4 marks)

Criteria	Marks
Choose 4 valid criteria to compare and gives correct comparison for all 4 (if more than 4 criteria given only first 4 are marked)	4
Gives correct comparison for 3 valid criteria	3
Gives correct comparison for 2 valid criteria	2
Gives correct comparison for 1 valid criterion	1

Sample answer

	AAS	COLOURIMETRY	UV-VIS SPECTROPHOTOMETRY
Light source	Hollow Cathode Lamp (HCL) that emits only light of wavelength of a specific metal	Visible light (tungsten/halogen lamp)	Visible light (tungsten/halogen lamp) & UV light (deuterium lamp)
How sample enters instrument	A solution is sprayed into a burner as an aerosol	A solution is added to a cuvette and placed in the colourimeter	A solution is added to a cuvette and placed in the spectrophotometer
What substances it can analyse	Metal ions	Coloured solutions (or non-coloured that have had a been coloured through a reaction)	Both inorganic and organic solutions
Qualitative or Quantitative analysis	Quantitative	Quantitative	Quantitative (for any molecule) and qualitative (for organic molecules)
Position/role of monochromator	After the sample. It only allows the specific wavelengths corresponding to the metal being tested to remove any light from other substances in the solution	Before the sample. This selects the wavelength corresponding to the complementary colour of the solution colour	Before the sample. This firstly selects all wavelengths from 200-800 nm (full spectrum scan) to find best one to use. Then it is set on the wavelength that is the best for absorption by the sample