Student Number……...

CHELTENHAM GIRLS' HIGH SCHOOL

2010

MID COURSE EXAMINATION

Chemistry

Total marks – 66

General Instructions
- Reading time – 5 minutes
- Working time – 2 hours
- Write using black or blue 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 number where required

This paper contains two parts, Part A and Part B

Part A – 16 marks
- Attempt Questions 1-16
- Allow about 30 minutes for this part

Part B – 50 marks
- Attempt Questions 17 – 26
- Allow about 1 hour and 30 minutes for this part

This examination is weighted 15% of your final school-based assessment mark

Part A – 16 marks
Attempt Questions 1-16
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.
Allow approximately 30 minutes for this part.

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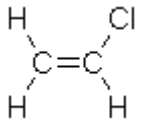
1 What is the systematic name for the following molecule?



(A) Chloroethane
(B) Chloroethene
(C) Vinyl chloride
(D) Styrene

2 Which of the following species is the strongest reductant?

(A) Iron
(B) Copper
(C) Iron (III) ions
(D) Copper (II) ions

3 Which one of the following statements about propene is **not** correct?

(A) It undergoes an addition reaction with hydrogen to form propane.
(B) It undergoes a polymerisation reaction expelling water in the process.
(C) Weak dispersion forces act between propene molecules and consequently it is a gas at room temperature.
(D) One propene molecule will react with excess oxygen to produce three molecules of water and three molecules of carbon dioxide.

4 Which of the following isotopes is most likely to undergo beta decay?

(A) Carbon-14
(B) Carbon-12
(C) Fluorine -19
(D) Fluorine -18

5 To determine the concentration of a sodium hydroxide solution, a student titrated it with a solution of hydrochloric acid of known concentration. Prior to commencing the titration, he washed and rinsed the equipment he was about to use.

Which of the following techniques was INCORRECT for his titration?

(A) The conical flask was rinsed with deionised water.

(B) The pipette was rinsed with a small aliquot of the sodium hydroxide solution.

(C) The burette was rinsed with deionised water.

(D) The sodium hydroxide was transferred into the conical flask using a pipette.

6 Which of the following substances would NOT be classified as amphiprotic?

(A) $H_2PO_4^-$

(B) HPO_4^{2-}

(C) H_3O^+

(D) H_2O

7 The reversible reaction to form ethanol from ethylene is represented:

$$C_2H_4\,(g) + H_2O\,(g) \overset{H_2SO_4}{\rightleftharpoons} C_2H_6O\,(g) \quad \Delta H = -45 \text{ kJ/mol}$$

Identify the <u>CORRECT</u> statement.

(A) The highest yield of ethanol is achieved at high temperature and low pressure.

(B) The dehydration of ethanol is an exothermic reaction.

(C) The highest yield of ethylene from ethanol is achieved when excess $H_2O(g)$ is present in the reaction vessel.

(D) Sulfuric acid acts as a catalyst for both the backward and forward reactions.

8 Identify which of the following is the conjugate acid of HPO_4^{2-}.

(A) HPO_4^{1-}

(B) $H_2PO_4^{1-}$

(C) H_3PO_4

(D) PO_4^{3-}

9 Radium-226 decays to produce Radon-222. Identify the other product that is released in this reaction.

(A) A neutron

(B) A gamma ray

(C) A beta particle

(D) An alpha particle

10 The heat of combustion of 1-propanol is 2016 kJ mol^{-1}.
What is the numerical value of the heat of combustion in kJ g^{-1}?

(A) 33.60

(B) 2016

(C) 3.360×10^4

(D) 1.210×10^5

11 According to the Lavoisier concept of acids and bases, an acid is a substance that

(A) contains oxygen.

(B) contains replaceable hydrogen.

(C) is capable of donating a hydrogen ion.

(D) increases the concentration of hydrogen ions in an aqueous solution.

12 A student constructed an electrochemical cell using a copper strip in a 1mol L^{-1} copper sulfate solution for one half-cell.
Identify how the chemicals should be disposed of at the end of her investigation.

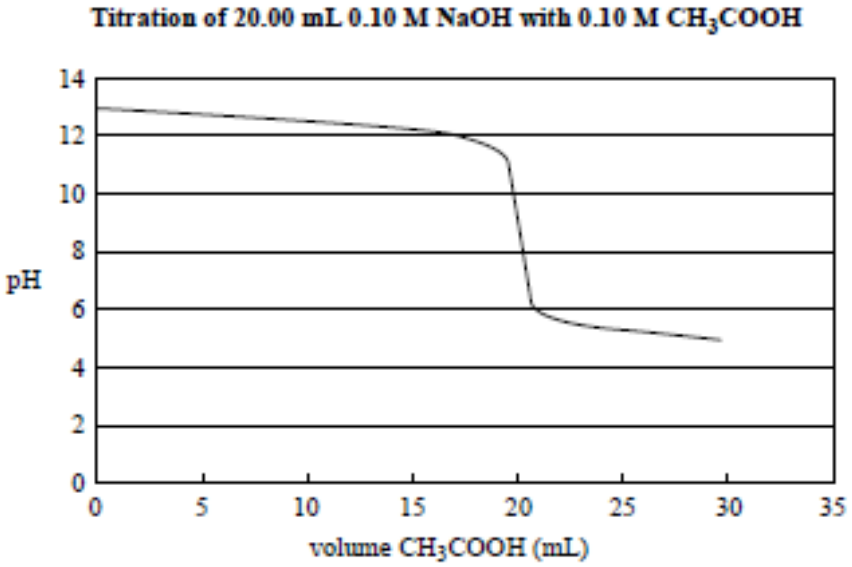
(A) The copper strip and the solution should be paced in a heavy metal waste bottle.

(B) The solution should be placed in a heavy metal waste bottle and the copper strip put in the bin.

(C) The solution should be poured down the sink and the copper strip placed in a heavy metal waste bottle.

(D) The solution should be diluted prior to being poured down the sink and the copper strip placed in a heavy metal waste bottle.

13 The graph below shows the change in pH of a reaction solution during a titration of 0.10 M NaOH with 0.10 M CH_3COOH.



A suitable indicator for the titration and the colour change observed is

	indicator colour	**change observed**
(A)	methyl red	yellow to red
(B)	methyl red	red to yellow
(C)	phenolphthalein	colourless to red
(D)	phenolphthalein	red to colourless

14 The sodium salt of propanoic acid (sodium propanoate) is used as a preservative in bread and other baked goods.
It can be produced by reacting propanoic acid with sodium hydroxide. In a particular experiment 100 mL of 0.080 M NaOH was added to 100 mL of 0.16 M propanoic acid.

Which of the following statements is/are correct?

I The pH of the resulting solution will be less than that of the propanoic acid solution.
II The resulting solution contains equal amounts of propanoic acid and its conjugate base.
III Before the NaOH was added there were no propanoate ions present.

(A) II only

(B) III only

(C) I and II only

(D) II and III only

15 When solid sodium hydride, NaH, is added to water, the hydride ion reacts according to the following equation.

$$H^-_{(aq)} + H_2O_{(l)} \rightarrow OH^-_{(aq)} + H_{2(g)}$$

This reaction can be classified as

(A) acid-base only.

(B) oxidation-reduction only.

(C) both acid-base and oxidation-reduction.

(D) neither acid-base nor oxidation-reduction.

16 The level of carbon dioxide in the air in a spacecraft can be controlled by passing the air through canisters containing lithium hydroxide, LiOH.
In a laboratory trial, the air in a 5.00 L container 25.0°C was passed through a canister of LiOH.
The final volume of the air, measured at 25.0°C, was found to be 4.50L.

The mass of CO_2 absorbed from the air sample by the LiOH in the canister was

(A) 0.89 g

(B) 9.77 g

(C) 10.6 g

(D) 116 g

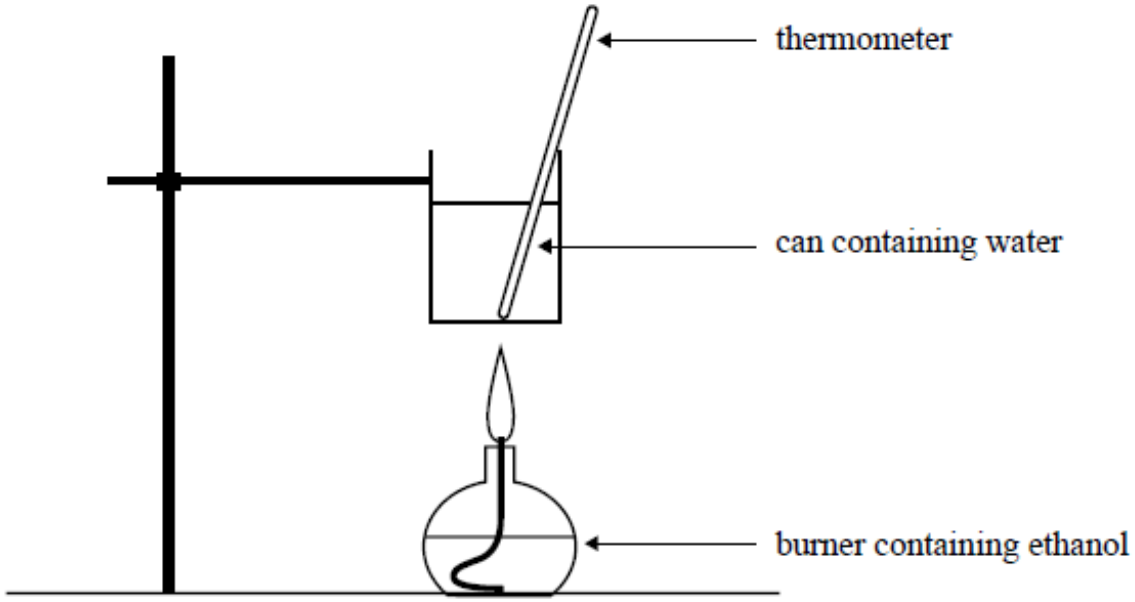
Part B – 50 marks

Attempt Questions 17-26
Write your answers in the spaces provided, showing working for calculations.
Allow approximately 1 hour and 30 minutes for this part.

Question 17 (3 marks)

Marks

2.09g of ethanol was used to heat 200 g of water in a can as shown in the following diagram.



If the initial temperature of water in the can: 25.3°C, calculate the final temperature of the water in the can.

Assume that 60% of the heat from the burning ethanol is transferred to the water and the molar heat of combustion for ethanol is 1364 kJ mol^{-1}. **3**

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Question 18 (6 marks) **Marks**

The hydrogen carbonate ion (HCO_3^-) is amphiprotic and a solution of the salt sodium hydrogen carbonate in water has a pH close to 8.

(a) Explain why the hydrogen carbonate ion is described as amphiprotic. Include TWO appropriate equations in your response. **2**

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(b) Explain why a solution of the salt sodium hydrogen carbonate in water has a pH close to 8. Include an equation in your response. **2**

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(c) A student wished to carry out a series of titrations and decided to use sodium hydrogen carbonate as a primary standard. **2**
Explain the characteristics of sodium hydrogen carbonate which make it suitable for use as a primary standard.

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Marks

Question 19 (5 marks)

A student was asked to confirm that an unknown solution was a ***weak base***, using ONLY TWO of the four indicators, phenolphthalein, methyl orange, bromothymol blue and litmus. **2**

(a) Outline a procedure that the student would use.

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(b) Describe how you prepared and tested a sample of a naturally occurring indicator. **3**

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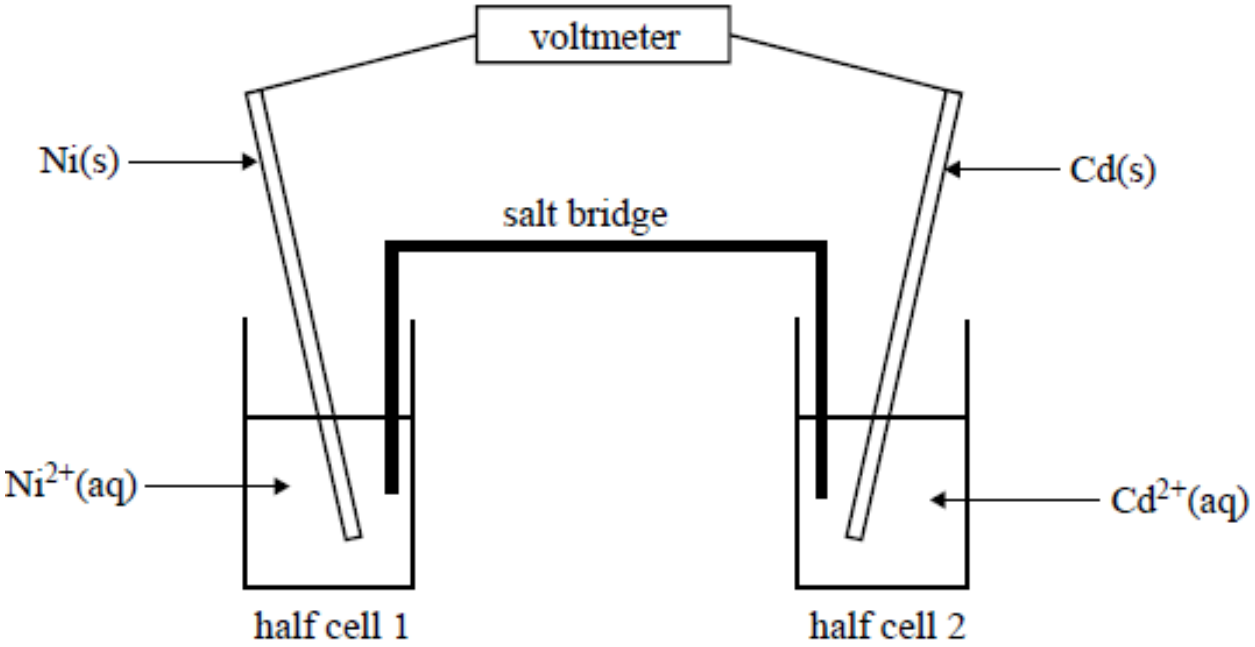
Question 20 (5 marks)

Marks

A galvanic cell is constructed from the following two half-cells under standard conditions.
Half-cell 1: a nickel electrode in a solution of 1.0 M nickel nitrate
Half-cell 2: a cadmium electrode in a solution of 1.0 M cadmium nitrate

A diagram of the cell is shown below.



(a) **On the above diagram,** draw an arrow to indicate the direction in which electrons will flow in the external circuit of this galvanic cell. *Hint:* The standard reduction potential for cadmium is -0.40 V. **1**

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(b) Give the equation for the half-reaction that takes place at the anode of this cell. **1**

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(c) Determine the net ionic equation for the overall cell reaction and hence calculate the overall potential difference for the cell. **2**

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(d) Identify one incorrect label in the above diagram. **1**

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Question 21 (4 marks)

Marks

A student was instructed to place strips of the metals magnesium and silver in a beaker containing copper (II) nitrate solution. The student was told to ensure that the metals did not touch each other. The student observed the beaker and contents over a period of 30 minutes. **4**

Identify THREE observations the student would have made as the reaction proceeded and write balanced equation(s) to explain these observations.

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Question 22 (4 marks)

Biopolymers are one group of chemicals being developed as replacements for materials currently obtained from the petrochemical industry.

(a) Identify a biopolymer currently being developed. **1**

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(b) Identify the specific enzyme(s) or organism used to synthesise the material. **1**

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(c) Describe a possible future direction of biopolymer research. **2**

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Question 23 (7 marks) **Marks**

Americium-241, an isotope of a transuranic element, undergoes alpha decay.

(a) Explain the term 'transuranic element'. **1**

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(b) Explain why the nuclei of transuranic elements are unstable. **2**

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(c) Write a balanced nuclear equation for the alpha decay of americium-241. **1**

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(d) Outline TWO different methods for production of transuranic elements. **2**

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(e) Identify one instrument which is used for detection of alpha radiation. **1**

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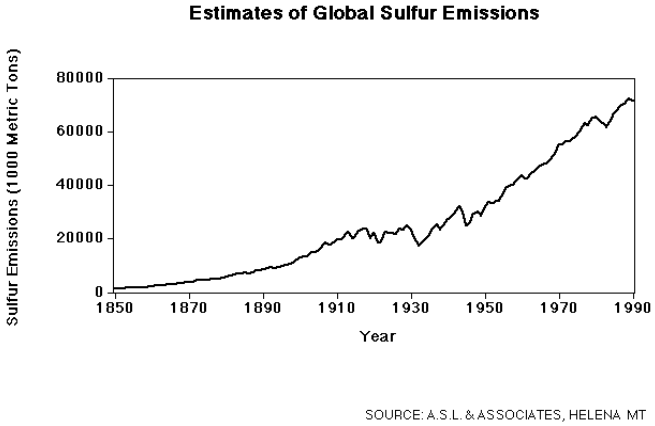
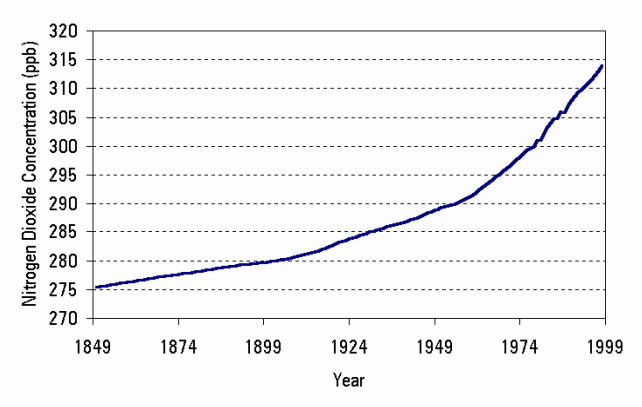
Question 24 (5 marks)

Marks

The graphs below show trends in the atmospheric concentrations of sulfur and nitrogen oxides.





(http://www.asl-associates.com/globals.htm) Figure 3: Historical Trends in Nitrogen Dioxide Concentration by Year

Source data: NASA Goddard Institute for Space Studies, http://www.giss.nasa.gov/data/si99/ghgases/

(extracted from http:// political-resources.com/misc/pegcc3/default.htm)

Account for the trends shown in the graphs. **5**

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Question 25 (5 marks)

0.415 g of a pure acid, $H_2X(s)$, is added to exactly 100 mL of 0.105 M NaOH(aq).
A reaction occurs according to the equation

$$H_2X(s) + 2NaOH(aq) \rightarrow Na_2X(aq) + 2H_2O(l)$$

The NaOH is in excess. This excess NaOH requires 25.21 mL of 0.197 M HCl(aq) for neutralisation.

(a) Calculate the amount, in mol, of NaOH that is added to the acid H_2X **initially**. **1**

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(b) Calculate the amount, in mol, of NaOH that reacts with the acid H_2X. **2**

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(c) Calculate the molar mass, in g mol^{-1}, of the acid H_2X **2**

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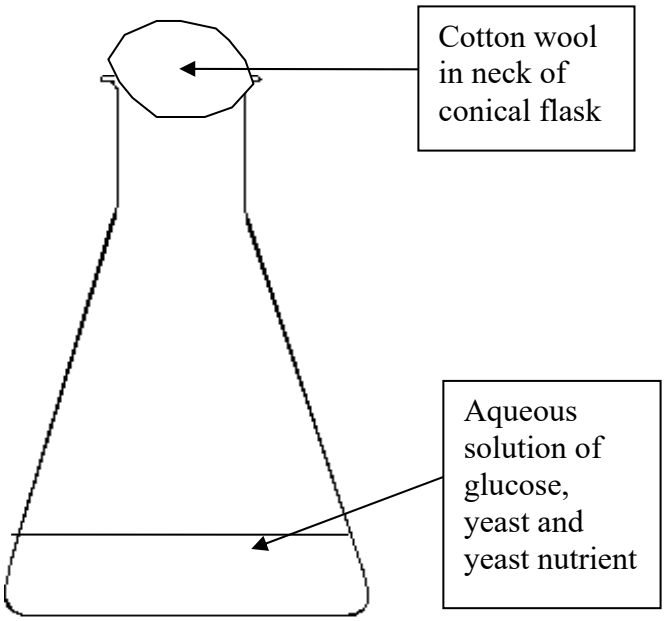
Marks

Question 26 (6 marks)

A student studying the mass changes that occur during fermentation set up the following equipment and left it in a warm place for a week. Each day she measured the mass of the flask, using an electronic balance. The table shows the data she collected.



Day	*Mass (g)*
1	461.05
2	456.95
3	453.40
4	453.36
5	453.35
6	453.31
7	453.28

(a) Assuming the loss in mass of the flask is caused by the loss of carbon dioxide gas, calculate the moles of carbon dioxide lost over the 7-day period. **1**

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(b) Calculate the mass of glucose which would have undergone fermentation during the 7-day period. Include a balanced equation in your response. **2**

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Question 26 (continued) **Marks**

(c) Assess the validity of this method of measuring the progress of the fermentation reaction. **3**

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END OF EXAMINATION

CHELTENHAM GIRLS' HIGH SCHOOL 2010 CHEMISTRY MID COURSE EXAMINATION

Marking guidelines and specimen answers

Part A. Total : **16** marks

1. **B** 2. **A** 3. **B** 4. **A** 5. **C**

6. **C** 7. **D** 8. **B** 9. **D** 10. **A**

11. **A** 12. **B** 13. **D** 14. **A** 15. **C**

16. **A**

Part B. Total : **50** marks

17

MARKING GUIDELINES (3 marks)

Criteria	Marks
Correctly calculates the final temperature of water	3
Correctly calculates the energy absorbed by the water	2
Correctly calculates the amount of ethanol burnt in moles	1

Specimen Answer

$n(CH_3CH_2OH) = 2.09 / (2 \text{ X } 12.01) + 16.00 + (6 \text{ x } 1.008)$
$= 2.09/ 46.068$
$= \underline{0.0447}$

Energy released by ethanol = 0.0447 x 1364
= 61.0 kJ

Energy absorbed by water = 0.6 x 61.0
= 37.1(29) kJ

Temperature increase = $\dfrac{37.1 \text{ x } 10^3}{0.2 \text{ x } 4.18 \text{ x } 10^3}$

= 44.4 °C

Final temperature = 25.3 + 44.4
= 69.7 °C

18

(a) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Explains why the hydrogen carbonate ion is described as amphiprotic AND • Writes TWO appropriate equations	2
• Explains why the hydrogen carbonate ion is described as amphiprotic OR • Writes TWO appropriate equations	1

Specimen Answer

An amphiprotic species is one that can either donate a proton (to a stronger base) or accept a proton (from a stronger acid).

As a base: $HCO_3^-(aq) + H_3O^+(aq) \rightleftharpoons H_2CO_3(aq) + H_2O(l)$

As an acid: $HCO_3^-(aq) + OH^-(aq) \rightleftharpoons CO_3^{2-}(aq) + H_2O(l)$

(b) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Explains why sodium hydrogen carbonate solution has a pH close to 8 AND • Writes an appropriate equation	2
• Explains why sodium hydrogen carbonate solution has a pH close to 8 OR • Writes an appropriate equation	1

Specimen Answer

The hydrogen carbonate ion acts as a base when placed in water. It accepts a proton from water and a hydroxide ion is formed. This means the hydroxide ion concentration is greater than the hydronium ions in water, so the solution is alkaline. The hydrogen carbonate ion is a weak base, so the concentration of hydroxide ions is small and the pH of 8 shows a weakly basic solution is formed.

$HCO_3^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + H_2CO_3(aq)$

18

(c) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Explains why sodium hydrogen carbonate is suitable for use as a primary standard AND • Identifies AT LEAST TWO suitable characteristics of sodium hydrogen carbonate	2
• Explains why sodium hydrogen carbonate is suitable for use as a primary standard OR • Identifies AT LEAST TWO suitable characteristics of sodium hydrogen carbonate	1

19

(a) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Outlines a valid procedure, using phenolphthalein and either bromothymol blue or litmus	2
• Outlines a procedure, using bromothymol blue or litmus to prove the unknown solution is basic	1

(b) **MARKING GUIDELINES** (3 marks)

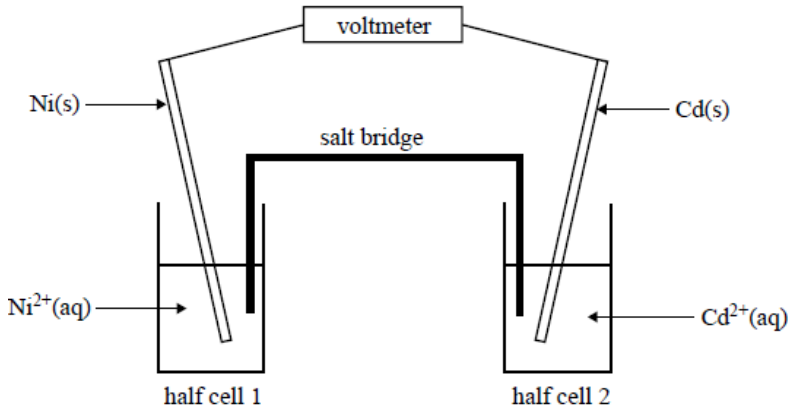
Criteria	Marks
• Describes thoroughly, in a logical sequence, the preparation and testing of a naturally occurring indicator	3
• Describes some aspects of the preparation AND testing of a naturally occurring indicator	2
• Describes some aspects of the preparation OR testing of a naturally occurring indicator	1

20

(a) **MARKING GUIDELINES** (1 mark)

Criteria	Marks
• Correctly indicates the direction in which electrons will flow in the external circuit	1

Specimen Answer ←



(b) **MARKING GUIDELINES** (1 mark)

Criteria	Marks
• Correctly writes a balanced equation for the anode half-reaction	1

Specimen Answer

$$Cd_{(s)} \rightarrow Cd^{2+}_{(aq)} + 2e^-$$

(c) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Determines the net ionic equation for the overall cell AND • Correctly calculates the overall potential difference for the cell	2
• Determines the net ionic equation for the overall cell OR • Correctly calculates the overall potential difference for the cell	1

Specimen Answer

$$Cd_{(s)} + Ni^{2+}_{(aq)} \rightarrow Cd^{2+}_{(aq)} + Ni_{(s)}$$

$$0.40 - 0.24 = \underline{0.16V}$$

20 (continued)

(d) **MARKING GUIDELINES** (1 mark)

Criteria	Marks
• Identifies an incorrect label on the diagram	1

Specimen Answer

The $Ni^{2+}_{(aq)}$ should be $Ni(NO_3)_{2\,(aq)}$

21

MARKING GUIDELINES (4 marks)

Criteria	Marks
• Identifies three observations the student would have made as reaction proceeded AND • Includes balanced equation(s) to explain these observations	4
• Identifies some observations the student would have made as reaction proceeded AND/OR • Includes balanced equation(s) to explain these observations	2 - 3
• Correctly identifies an observation the student would have made as reaction proceeded OR • Includes a balanced equation that determines the observations	1

Specimen Answer

A reaction occurs between the magnesium metal and the copper ions. The magnesium metal becomes copper coloured on the part of the strip in the solution. The copper solution becomes lighter in colour as the reaction progresses. Both of these observations are due to the reduction of the copper ions.

$$\text{i.e. } Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$$

Later, the copper coloured magnesium will start to disintegrate, due to the oxidation of the magnesium metal.

$$Mg_{s)} \rightarrow Mg^{2+}_{(aq)} + 2e^-$$

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22

(a) **MARKING GUIDELINES** (1 mark)

Criteria	Marks
• Correctly identifies a biopolymer	1

(b) **MARKING GUIDELINES** (1 mark)

Criteria	Marks
• Correctly identifies the organism used to synthesise biopolymer	1

(c) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Correctly describes a possible research direction	2
• Correctly identifies a possible research direction	1

23

(a) **MARKING GUIDELINES** (1 mark)

Criteria	Mark
• Correct explanation of 'transuranic element'	1

Sample answer

A transuranic element has an atomic number greater than uranium, i.e. greater than 92.

(b) **MARKING GUIDELINES** (2 marks)

Criteria	Mark
Correctly explains in terms of n/p ratio or zone of stability	2
Correctly identifies in terms of n/p ratio or zone of stability	1

Specimen Answer

The nuclei of transuranic elements are big, with a n/p ratio which is too high and outside the 'zone of stability' (n/p > 1.5). The transuranic nuclei most commonly reduce the ratio by emitting either alpha particles (2p and 2n) or (less commonly) beta particles – high-speed electrons formed when a neutron changes to a proton and electron, thus reducing the n/p ratio.

23 (continued)

(c) **MARKING GUIDELINES** (1 mark)

Criteria	Mark
• Correct nuclear equation	1

Sample answer

$^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}He$

(d) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Outlines TWO different methods for production of transuranic elements	2
• Outlines ONE method for production of transuranic elements	1

Specimen Answer

Transuranic elements can be made by bombarding nuclei with neutrons in a nuclear reactor OR by bombarding heavy nuclei with high speed positively charged particles (such as protons, alpha particles or other nuclei) in a machine called an accelerator (a linear accelerator or a cyclotron).

(e) **MARKING GUIDELINES** (1 mark)

Criteria	Mark
• Identifies an instrument which detects alpha radiation	1

Sample answer

Geiger counter.

24

MARKING GUIDELINES (5 marks)

Criteria	Marks
Correctly identifies increasing rate of emissions and links this to increasing rates of combustion of coal and petroleum	4 - 5
Correctly links increasing emissions to increasing use of fossil fuels	2 - 3
Correctly identifies the trends shown in the graphs	1

25

(a) **MARKING GUIDELINES** (1 mark)

Criteria	Marks
Correctly calculates the moles of NaOH added	1

Specimen Answer

Number of moles NaOH added = $0.105 \times 100 \times 10^{-3}$

= 1.05×10^{-2} moles

(b) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
Correctly calculates the moles of NaOH that neutralises the acid	2
Correctly calculates the moles of NaOH in excess	1

Specimen Answer

Number of moles of NaOH in excess = number of moles of hydrochloric acid

= $0.197 \times 25.21 \times 10^{-3}$

= 4.97×10^{-3} moles

Number of moles used in neutralisation = $0.0105 - 0.00497$

= 5.53×10^{-3} moles

(c) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
Correctly calculates the molar mass of the acid H_2X	2
Correctly calculates the moles of acid H_2X	1

Specimen Answer

Number of moles of H_2X = 0.5 x number of moles of NaOH

= $0.5 \times 5.53 \times 10^{-3}$

= 2.765×10^{-3} moles

Molar mass = $\frac{m}{n}$

= $\frac{0.415}{2.765 \times 10^{-3}}$

= 150 g mol^{-1}

26

(a) **MARKING GUIDELINES** (1 mark)

Criteria	Mark
• Correct number of moles of carbon dioxide	1

Specimen Answer

Loss in mass of flask over 7-day period = 461.05 – 453.28 g = 7.77 g
Moles of CO_2 *(g)* lost over 7-day period = 7.77/44.01 = 0.177 mol

(b) **MARKING GUIDELINES** (2 marks)

Criteria	Marks
• Writes a correctly balanced equation for the fermentation of glucose AND • Calculates the mass of glucose which has been fermented	2
• Writes a correctly balanced equation for the fermentation of glucose OR • Calculates the mass of glucose which has been fermented	1

Specimen Answer

$$C_6H_{12}O_6\ (aq) \xrightleftharpoons{\text{Yeast}} 2C_2H_6O\ (aq) + 2CO_2\ (g)$$

0.177 mol of carbon dioxide is produced from 0.177/2 mol glucose

Hence moles of glucose fermented = 0.0885 mol
Hence mass of glucose fermented = 0.0885 x 180.18 g = 15.9 g (to 3 significant figures)

(c) **MARKING GUIDELINES** (3 marks)

Criteria	Marks
• Assesses the validity of the method AND • Identifies how the method is used in measuring the progress of the fermentation reaction AND • Identifies a limitation in the method	3
• Identifies how the method is used in measuring the progress of the fermentation reaction AND • Identifies a limitation in the method	2
• Identifies how the method is used in measuring the progress of the fermentation reaction OR • Identifies a limitation in the method	1