2008
Higher School Certificate
Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A data sheet and a Periodic Table are provided
- Write your student number and/or name at the top of every page

Total marks - 100

Section I – Pages 2 – 20
Total marks (75)
This section has two parts, Part A and Part B

Part A
Total marks (15)
Attempt Questions 1 – 15
Allow about 30 minutes for this part

Part B
Total marks (60)
Attempt Questions 16 – 28
Allow about 1 hour 45 minutes for this part

Section II – Pages 21 – 44
Total marks (25)
Attempt ONE question from Questions 26 – 30
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: .....

STUDENT NUMBER/NAME: .....

Section I

Total marks (75)

Part A
Total marks (15)
Attempt Questions 1 – 15
Allow about 30 minutes for this part

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
1				
2				
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15				

1. The reaction between a particular hydrocarbon and bromine produces the following product:

$$CH_3CHBrCHBrCH_3$$

Which of the following hydrocarbons was reacted with bromine to produce this product?

(A) 1-propene
(B) Butane
(C) 2-butene
(D) Propane

2. The heat of combustion of methanol is 22.7 kJ g^{-1}.

Which of the following is the theoretical mass of water that could be heated from 25^0C to 53^0C using the heat produced by the complete combustion of 0.5 g of methanol?

(A) 97 g
(B) 0.097 g
(C) 194 g
(D) 0.194 g

3. Which of the following equations correctly represents the production of a transuranic element?

(A) $^{59}_{27}Co + {}^{1}_{0}n \longrightarrow {}^{60}_{27}Co$

(B) $^{238}_{92}U + {}^{1}_{0}n \longrightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$

(C) $^{239}_{93}Np \longrightarrow {}^{235}_{91}Pa + {}^{4}_{2}He$

(D) $^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

4. Which fuel delivers the lowest proportion of carbon dioxide in its combustion products?

(A) Methane
(B) Ethanol
(C) Ethylene
(D) Propane

5. A radioisotope is to be used in a gauge to monitor the thickness of aluminium foil as it is formed.

Which of the following isotopes is suitable for this purpose?

(A) A long-lived alpha source
(B) A short-lived gamma source
(C) A long-lived beta source
(D) A long-lived gamma source

6. Which combination of solutes forms a buffer solution in water?

(A) Nitric acid and potassium nitrate
(B) Citric acid and potassium citrate
(C) Hydrochloric acid and sodium hydroxide
(D) Ammonia and potassium nitrate

7. Which of the following is the characteristic which is present in the conjugate base of any Bronsted-Lowry acid?

(A) A negative charge
(B) A coordinate covalent bond
(C) A hydroxide ion
(D) An unshared electron pair

8. Which oxide is the most strongly acidic?

(A) Sodium oxide
(B) Sulfur trioxide
(C) Carbon dioxide
(D) Silicon dioxide

9. A 20 mL volume of 0.010 mol L^{-1} nitric acid solution is diluted to 100 mL.

Which of the following is the change in pH for the nitric acid solution after this dilution?

(A) From 2.0 to 2.7
(B) From 4.0 to 9.0
(C) From 1.7 to 1.0
(D) From 2.0 to 2.5

10. In aqueous solution aluminium ions (Al^{3+}) react with water producing insoluble aluminium hydroxide in the following equilibrium:

$$Al^{3+}_{(aq)} + 3H_2O_{(l)} \leftrightarrow Al(OH)_{3\,(s)} + 3H^{+}_{(aq)}$$

Under which conditions are aluminium ions likely to be found at high concentrations in aqueous solution?

(A) pH > 7
(B) pH = 7
(C) pH < 7
(D) The concentration would be unaffected by pH

11. Nitric oxide is a colourless gas. It reacts with oxygen in an equilibrium in which dark brown nitrogen dioxide is formed.

$$NO(g) + \tfrac{1}{2}O_2(g) \longleftrightarrow NO_2(g) \quad \triangle H = -56 \text{ kJ mol}^{-1}$$

colourless dark brown

Which of the following combination of conditions results in the deepest brown colour for the equilibrium system?

	Temperature	*Pressure*	*$[O_2]$*
(A)	Low	Low	Low
(B)	High	High	Low
(C)	High	Low	High
(D)	Low	High	High

12. For which of the following was the Haber process originally developed?

(A) Plastics
(B) Explosives
(C) Fertilisers
(D) Dyes

13. Boron trifluoride reacts with the fluoride ion to form the tetrafluoroborate ion:

$$BF_3 + F^- \rightarrow BF_4^-$$

Which type of bond forms in this reaction?

(A) Normal covalent
(B) Polar covalent
(C) Coordinate covalent
(D) Ionic

14. In which layer of the atmosphere is ozone a pollutant?

(A) Stratosphere
(B) Upper troposphere
(C) Tropopause
(D) Lower troposphere

15. Which of the following is a pair of isomers?

(A) 1-propanol and 2-propanol
(B) Dichloromethane and difluoromethane
(C) Dichloromethane and 1,1-dichloroethane
(D) 1,2-dichloroethane and 1,2-dichloroethene

Section I (continued)

Part B
Total marks (60)
Attempt Questions 16 – 28
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 16 (9 marks) **Marks**

Polyvinyl alcohol is a water-soluble addition polymer used in adhesives and paints. The monomer is vinyl alcohol (ethenol) with the structure:

$$CH_2 = CHOH$$

(a) Construct a structural formula for a 3-unit segment of the polymer. **1**

(b) Describe how bromine water can be used to distinguish between a solution of the monomer and a solution of the polymer. **1**

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(c) Explain the affinity of this polymer to water. **1**

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Question 16 continues on the next page

Question 16 (continued) **Marks**

(d) This polymer is thermoplastic and is made into flexible film for plastic bags and wrapping.

Outline an advantage AND a disadvantage of using this polymer rather than polyethylene. **2**

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(e) Polyvinyl alcohol can be reacted with acetic acid to form polyvinyl acetate.

(i) Describe the reaction conditions you would use to produce polyvinyl acetate in this reaction. **2**

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(ii) Predict the solubility of polyvinyl acetate in water with reference to its molecular properties. **2**

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End of Question 16

Question 17 (7 marks) **Marks**

The table below compares some properties of the vehicle fuels: octane and ethanol.

Property	Octane	Ethanol
Molar mass (g)	114	46
Boiling point (°C)	126	78
Density (g L^{-1})	700	790
Solubility in water	0	100%
Heat of combustion kJ mol^{-1}	5 500	1 371
Heat of combustion kJ g^{-1}		
Heat of combustion kJ L^{-1}		

(a) Calculate the heat of combustion of EACH fuel in kJ g^{-1}, and hence the value per litre.

Show your working below and enter your answers in the table above. **2**

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(b) Explain why ethanol-fuelled vehicles use 30% more fuel than similar octane-driven vehicles. **2**

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Question 17 continues on the next page

Question 17 (continued) **Marks**

(c) Ethanol is widely advocated as a preferable fuel to petrol.

Assess the issues surrounding the use of ethanol as a fuel for vehicles. **3**

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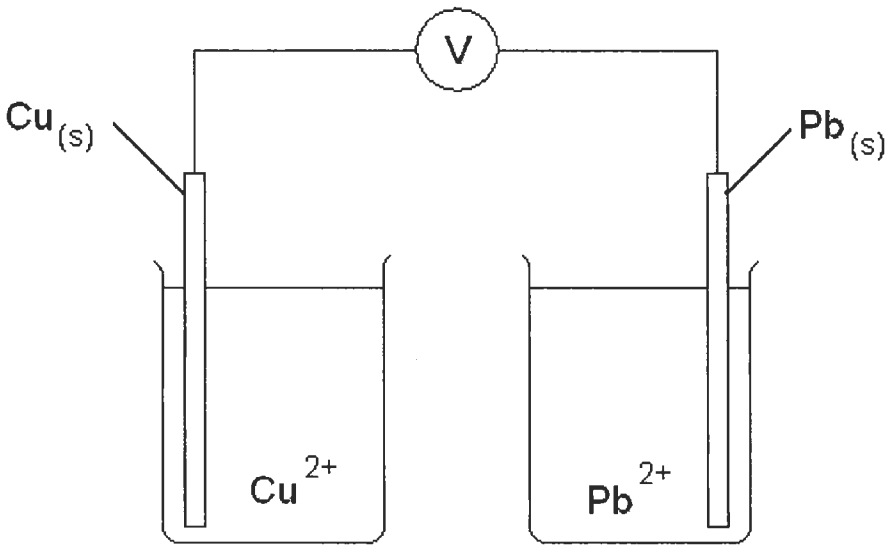
End of Question 17

Question 18 (5 marks) **Marks**

The diagram below shows a partially constructed galvanic cell.



(a) On the above diagram:

(i) Show any extra components that would be required to allow this galvanic cell to operate. **1**

(ii) Label these extra components as well as the anode and cathode. **1**

(iii) Trace the direction of electron flow. **1**

(b) Write an ionic equation to represent the overall reaction occurring in this galvanic cell. **1**

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(c) Calculate the theoretical voltage generated by this cell under standard conditions. **1**

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End of Question 18

Question 19 (3 marks) **Marks**

The rechargeable lithium ion cell is now used in most laptop computers, delivering 3.7 volts. The electrode reactions during discharge can be represented by:

$$Li(s) \rightarrow Li^+ + e^-$$

$$Li^+ + CoO_2(s) + e^- \rightarrow LiCoO_2(s)$$

(a) Referring to the position of lithium in the Periodic table and its standard reduction potential of -3.0v, identify its advantages in portable cells. **2**

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(b) All lithium cells use organic solvents containing a compound such as $LiClO_4$.

Referring to the Data Sheet provided, explain why aqueous solvents CANNOT be used. **1**

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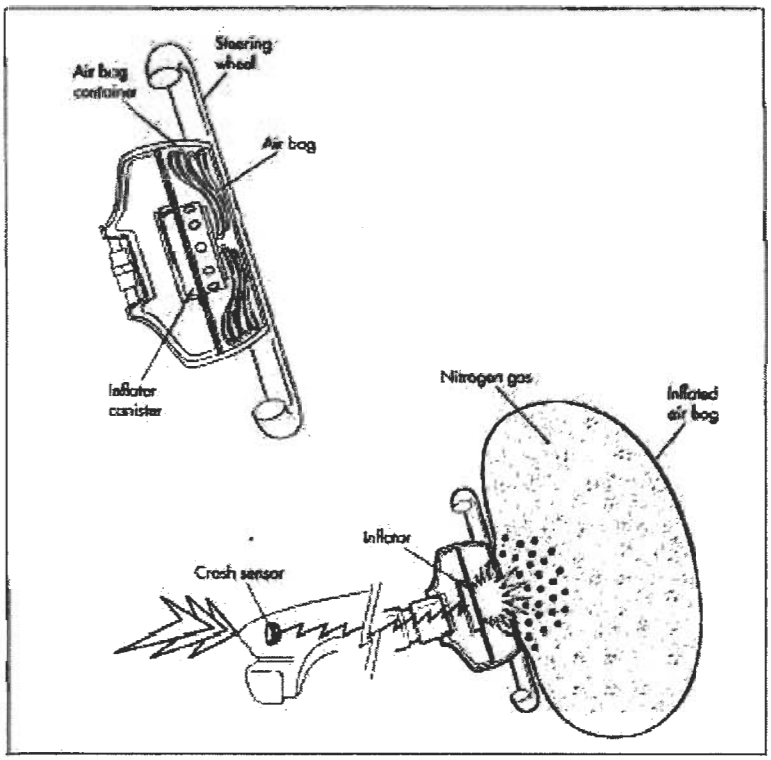
End of Question 19

Question 20 (7 marks) **Marks**

Less than 50 milliseconds after a violent collision a car airbag fills with nitrogen gas, produced by reactions in a solid mixture of sodium azide (NaN_3), potassium nitrate and silicon dioxide.



As shown in the diagram above, the igniter triggers the exothermic decomposition of sodium azide into its elements.

(a) Sketch an energy profile for this decomposition. **1**

Question 20 continues on the next page

Question 20 (continued) **Marks**

(b) Calculate the mass of sodium azide required to fill an airbag with 60 L of nitrogen at 298 K and 100 kPa. **2**

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(c) Sodium from the first reaction then reacts with potassium nitrate to form a mixture of sodium oxide and potassium oxide.

(i) Describe how sodium may be hazardous without this reaction taking place. **1**

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(ii) Identify the acid-base properties of these oxides which may also be hazardous to the car occupants. **1**

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(d) Demonstrate how the acid-base properties of silicon dioxide enable the safe removal of sodium and potassium oxide to form harmless silicate salts. **2**

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End of Question 20

Question 21 (9 marks) **Marks**

Two unlabelled bottles contain colourless solutions; both with a pH of 3.0.

25.0 mL samples from each solution are titrated with a standard solution of 0.12 mol L^{-1} sodium hydroxide. The titration results are:

Solution	Volume of standard solution used (mL)	
	Solution A	Solution B
1st titration	0.20	13.2
2nd titration	0.25	13.1
3rd titration	0.20	13.1

(a) Calculate the acid concentration in EACH container, assuming both acids are monoprotic. **2**

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(b) Identify a suitable indicator for these titrations and justify your choice. **2**

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(c) Identify the instrument used to obtain 25 mL samples of the acids and describe the procedure followed when changing from one acid to the other. **2**

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Question 21 continues on the next page

Question 21 (continued) **Marks**

(d) Identify a possible acid for EACH container and account for the difference in titration results. **3**

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Question 22 (7 marks)

A number of Mount Isa children were found with blood lead levels above the recommended maximum of 10 μg per 100 mL.

(a) Express the maximum recommended level of lead in parts per million (ppm). **1**

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(b) Identify a reagent to detect lead ions in solution. Construct an ionic equation for this reaction. **1**

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(c) Explain why atomic absorption spectrometry (AAS) is a more suitable method for analysing lead levels in blood, soil and surface water. **1**

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Question 22 continues on the next page

Question 22 (continued) **Marks**

(d) Outline a procedure you would follow to produce a standard solution of lead ions at a concentration of 10 μg/100 mL, starting with a small quantity of lead nitrate crystals. **2**

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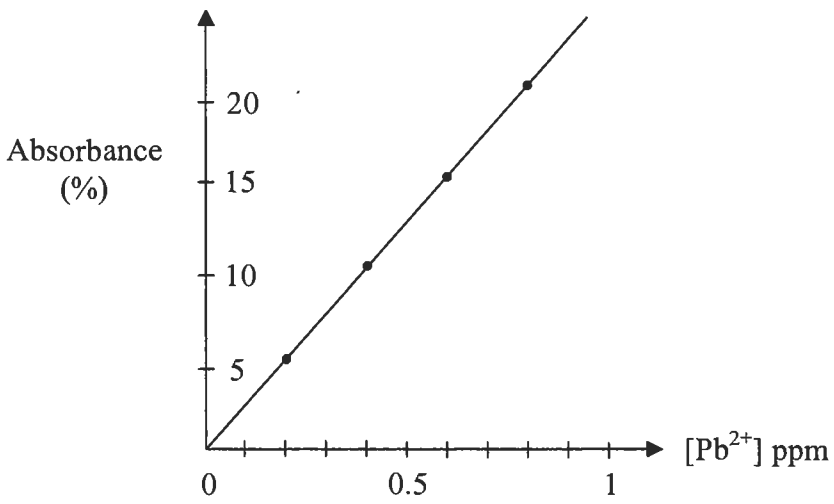
(e) The graph below shows AAS results for a standard solution of lead ions.



One blood sample returns an AAS lead absorbance of 7%.

Calculate the concentration of lead ions in μg/100 mL. **2**

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End of Question 22

Question 23 (5 marks) **Marks**

One harmful effect of the Burma cyclone in May 2008 was the invasion by seawater into rice paddies and other freshwater areas.

(a) Describe problems caused by salinity in this situation. **1**

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(b) Seawater is mainly a mixture of metal chlorides and sulphates.

Outline a chemical procedure to measure the extent of seawater contamination, analysing for the sulfate ion. **3**

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(c) Identify a simple physical test to cross-check your chemical analysis. **1**

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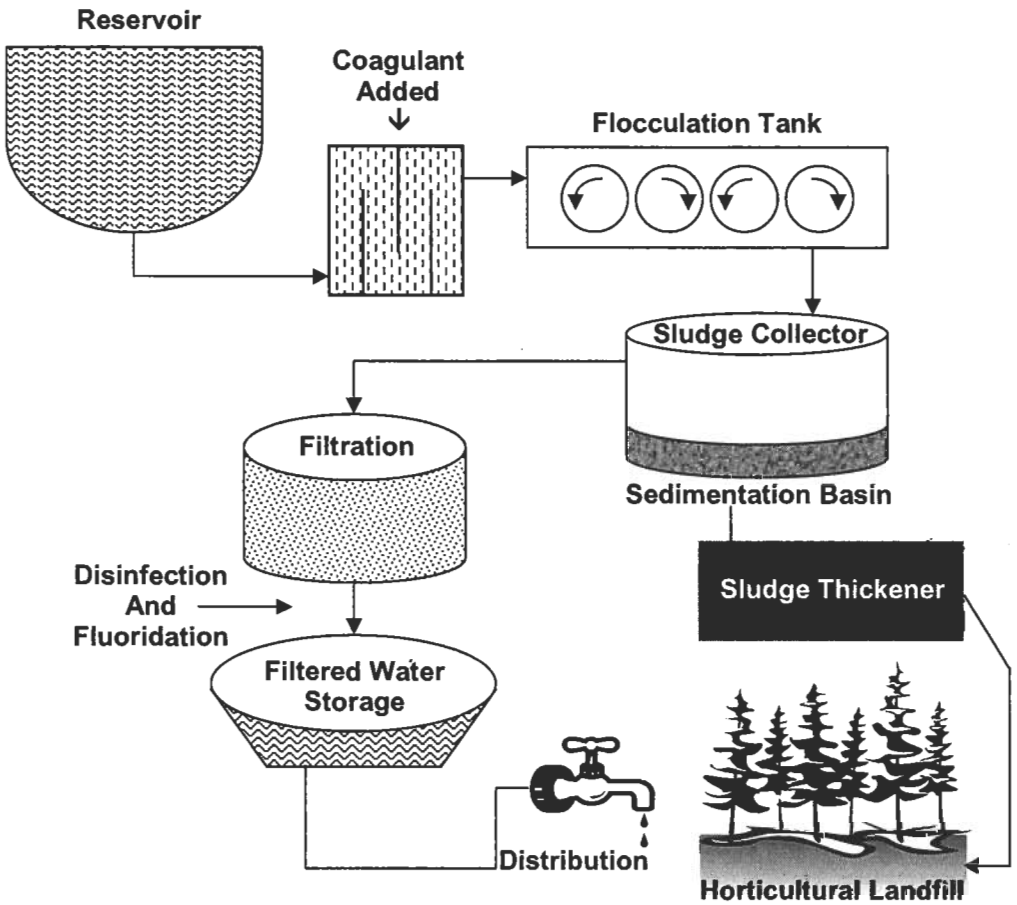
End of Question 23

Question 24 (4 marks) **Marks**

The diagram shows the main stages in a treatment system for a town water supply.



(a) Distinguish between the processes of filtration and sanitisation.

In your answer identify ONE chemical used to sanitise water. **2**

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Question 24 continues on the next page

Question 24 (continued) **Marks**

(b) After potentially harmful microbes were found to be present in Sydney's sanitised water, micro-membrane filters were installed.

Describe the structure and function of micro-membrane filters. **2**

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Question 25 (4 marks)

(a) Explain why the yield from the Haber process is reduced at higher temperatures. **2**

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(b) Identify a catalyst for the Haber reaction and explain why it lowers the temperature required for the reaction. **2**

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End of Section I

STUDENT NUMBER/NAME: .....

Section II

Total marks (25)
Attempt ONE question from Questions 29 – 33
Allow about 45 minutes for this section

Answer the question on your own paper or writing booklet, if provided.

Show all relevant working in questions involving calculations.

Question 26 – Industrial Chemistry (25 marks) **Marks**

(a) Compare the composition, mode of action and relative advantages of soaps and non-ionic detergents. **5**

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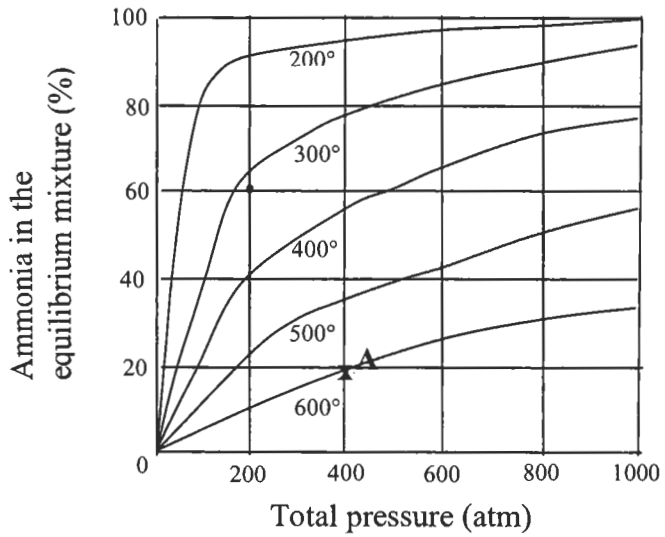
Question 26 continues on the next page

Question 26 (continued) **Marks**

(b) The graphs below show the molar fraction (%) of ammonia present at equilibrium when ammonia gas is placed in a pressure vessel with a catalyst.



(i) Explain why a 90% yield of ammonia is not practicable in the Haber process. **2**

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(ii) 1.0 L of a gas mixture, at a pressure of 400 atm and temperature of 600°C, contains a total of 5.56 moles of gas molecules. Calculate the equilibrium constant for the production of ammonia, at point A on the graph, and describe the effect of temperature on the equilibrium constant. **3**

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Question 26 continues on the next page

Question 26 (continued) **Marks**

(iii) When the pressure on a gas mixture is doubled, the concentration of all gases present in the mixture is doubled. With reference to the equilibrium constant expression, explain why doubling the pressure on the equilibrium system referred to in the graph results in an increased percentage of ammonia. **2**

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(c) During your practical work you performed a first-hand investigation to observe the reactions of sulfuric acid as an oxidising agent and as a dehydrating agent.

(i) Describe safety precautions that must be taken when using concentrated sulfuric acid. **1**

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(ii) Outline the procedure used in your investigation and describe the results obtained. **3**

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Question 26 continues on the next page

Question 26 (continued) **Marks**

(d) (i) Identify THREE useful products from the electrolysis of sodium chloride solution. **2**

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(ii) Assess advantages of the membrane cell for the industrial electrolysis of sodium chloride in comparison with the diaphragm cell and mercury cell. **3**

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(e) Identify environmental issues associated with the Solvay process and assess the merits of a competing electrolytic process in which waste carbon dioxide (from combustion) is passed into the cathode region of a sodium chloride cell, to react with sodium hydroxide. **4**

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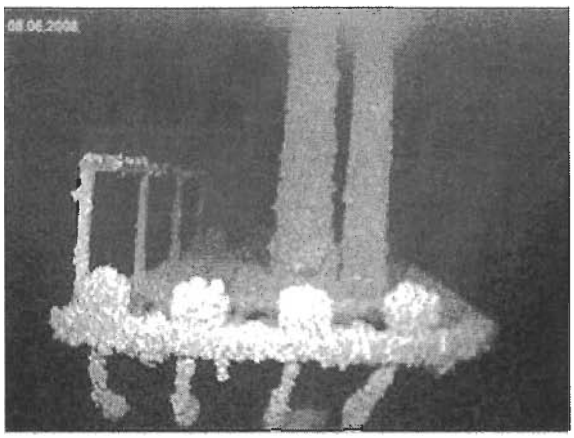
End of Question 26

Question 27 – Shipwrecks, Corrosion and Conservation (25 marks) **Marks**

(a) The underwater photograph shows part of the main mast and crow's nest of the wreck of HMS Ontario, a wooden British warship that sank in the cold deep freshwater of Lake Ontario in 1780. Discovered only in 2008, the wreck is described as almost perfectly preserved.



Contrast the environmental conditions which have preserved this wreck with those that have resulted in the extensive decay of more recent oceanic wrecks. **4**

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Question 27 continues on the next page

Question 27 (continued) **Marks**

(b) Galvanised roofing consists of steel sheets coated with a thin layer of an alloy of zinc and aluminium.

(i) Describe and explain the protection given to steel by the galvanised layer. **4**

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(ii) The manufacturer warns that roofing sheets must not be marked with ordinary graphite pencils.

Use your knowledge of electrochemical cells to justify this warning. **2**

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Question 27 continues on the next page

Question 27 (continued) **Marks**

(c) During your course you conducted a first-hand investigation to identify the factors that affect the rate of an electrolysis reaction.

(i) Construct the half-cell reaction equations for the cell used in your investigation, and the overall cell reaction. **3**

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(ii) Identify TWO factors which affected the rate of the reaction and describe their effects. **2**

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(iii) Outline ONE application of electrolysis in preserving artefacts from a wreck. **2**

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Question 27 continues on the next page

Question 27 (continued) **Marks**

(d) (i) Describe the problems associated with preserving seawater-saturated, wooden artefacts when they are brought to the surface. **2**

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(ii) Outline procedures for the long-term preservation of these artefacts. **3**

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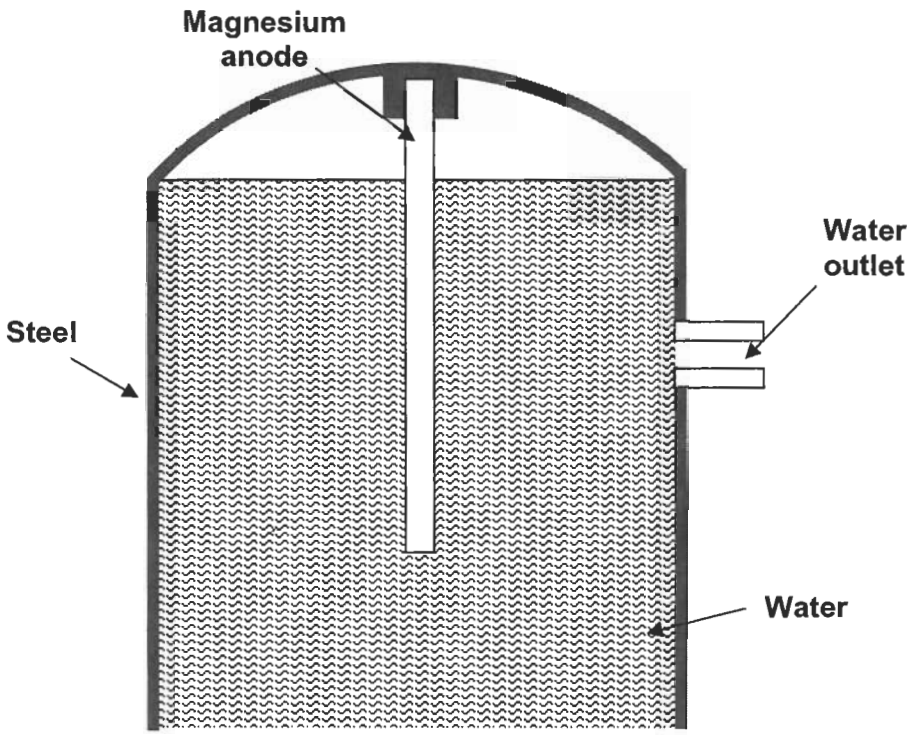
Question 27 continues on the next page

Question 27 (continued) **Marks**

(e) Steel-based hot water storage tanks are fitted with a central magnesium rod which is bolted to the top of the tank and suspended in the water.



Explain the function of the magnesium rod and the expected result if it were substituted with a copper rod. **3**

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End of Question 27

Question 28 – The Biochemistry of Movement (25 marks) **Marks**

(a) Identify the general formula for fatty acids. **1**

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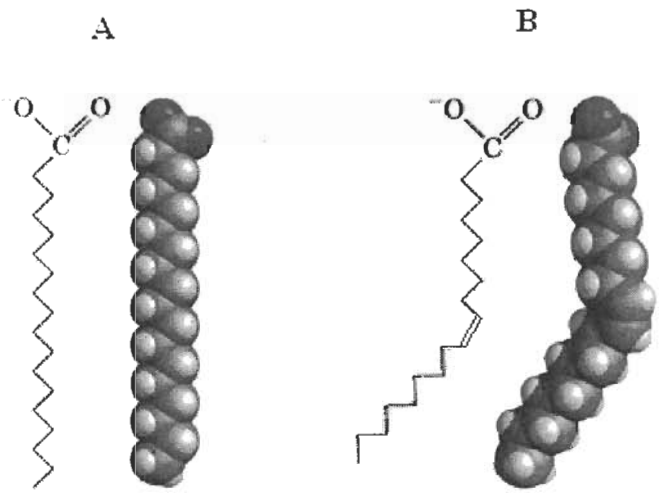
(b) Observe the following images.



(i) On the diagram above, circle the part of the molecules that will mix with water. **1**

(ii) Describe the solubility of these molecules. **3**

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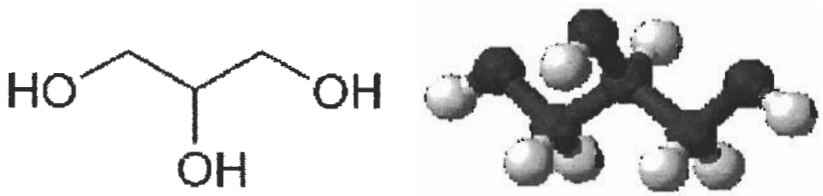
Question 28 continues on the next page

Question 28 (continued) **Marks**

(c) Observe the following images.



Identify the common and systematic names of the molecule shown above. **2**

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(d) Using a diagram, demonstrate the formation and structure of a peptide bond. **3**

(e) Using an example, explain the specificity of an enzyme substrate-binding site. **5**

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Question 28 continues on the next page

Question 28 (continued) **Marks**

(f) (i) Identify the significance of mitochondria. **1**

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(ii) Define the term *oxidative phosphorylation*. **2**

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(iii) Outline the effects of anaerobic respiration. **4**

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Question 28 continues on the next page

Question 28 (continued) **Marks**

(g) During your study of "The Biochemistry of Movement" you performed a first-hand investigation to compare the structures of glycogen and glucose from diagrams or models.

Outline the results of your investigation.

In your answer refer to the structure of glucose and glycogen. **3**

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End of Question 28

STUDENT NUMBER/NAME: .....

Question 29 – Chemistry of Art (25 marks) **Marks**

(a) Identifying ONE example from EACH group, outline reasons for the use of oxides, sulfides and carbonates of transition metals in traditional pigments. **6**

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Question 29 continues on the next page

Question 29 (continued) **Marks**

(b) During your practical work you performed a first-hand investigation to demonstrate the range of oxidation states of a transition metal.

(i) In terms of its electronic structure, explain why your chosen metal has a range of oxidation states. **3**

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(ii) Outline the procedure used in your investigation and describe the results obtained. **3**

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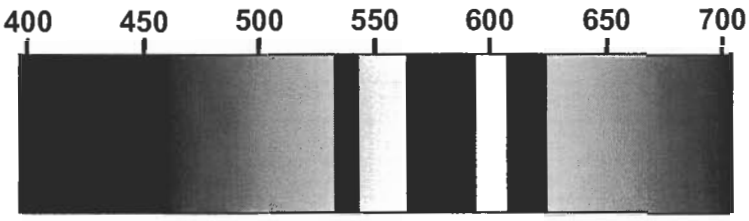
Question 29 continues on the next page

Question 29 (continued) **Marks**

(c) Cobalt glass, containing cobalt oxide, is often used in flame tests to overcome the problem of contamination by sodium ions, which emit an intense yellow line at 589 nm wavelength.

The diagram below shows the absorption spectrum of cobalt glass.



(i) Distinguish between an emission spectrum and an absorption spectrum. **2**

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(ii) Explain how cobalt glass overcomes the problem of sodium impurities in a flame test for potassium ions. **3**

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Question 29 continues on the next page

Question 29 (continued) **Marks**

(d) The table below shows the first eight successive ionisation energies for the vanadium atom.

Ionisation	Ionisation energy (kJ mol^{-1})
1st	648
2nd	1 370
3rd	2 870
4th	4 600
5th	6 280
6th	12 400
7th	14 600
8th	16 700

(i) Draw the complete electronic structure of the vanadium(II) ion. **2**

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(ii) Using data from the table, explain why vanadium shows its maximum oxidation state in the vanadate ion VO_3^-. **3**

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Question 29 continues on the next page

Question 29 (continued) **Marks**

(e) Ethylenediamine (1,2-diaminoethane) is a chelating agent for metal ions, with the molecular structure $NH_2CH_2CH_2NH_2$.

With the aid of a diagram, demonstrate that ethylenediamine (ED) possesses the necessary structural features to act as a chelating agent in the ion $[Co(ED)_3]^{3+}$. **3**

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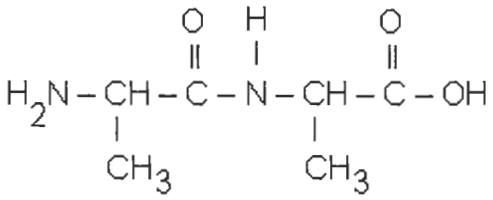
End of Question 29

STUDENT NUMBER/NAME: .....

Question 30 – Forensic Chemistry (25 marks) **Marks**

(a) (i) Consider the dipeptide shown below.



Draw the structure of alanine, the amino acid used to produce this dipeptide. **1**

(ii) Identify the differences that allow alanine to be separated from other amino acids using electrophoresis. **1**

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(iii) Describe the pH conditions that would cause molecules of alanine to migrate towards the positive electrode during electrophoresis. **2**

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Question 30 continues on the next page

Question 30 (continued) **Marks**

(b) (i) Describe the difference between a "disaccharide" and a "polysaccharide". **1**

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(ii) Explain how analysis of polysaccharides can determine whether a sample has animal or plant origins. **3**

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(c) Discuss the use of destructive analysis in forensic chemistry. **4**

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Question 30 continues on the next page

Question 30 (continued) **Marks**

(d) Describe a chemical test that could be used to distinguish between the following pairs of compounds:

(i) Glucose and sucrose. **2**

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(ii) 1-propanol and propanoic acid. **2**

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Question 30 continues on the next page

Question 30 (continued) **Marks**

(e) Assess the role of DNA analysis in forensic chemistry. **5**

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Question 30 continues on the next page

Question 30 (continued) **Marks**

(f) (i) Explain why the emission spectrum produced by atoms of sodium is different to that produced by calcium. **2**

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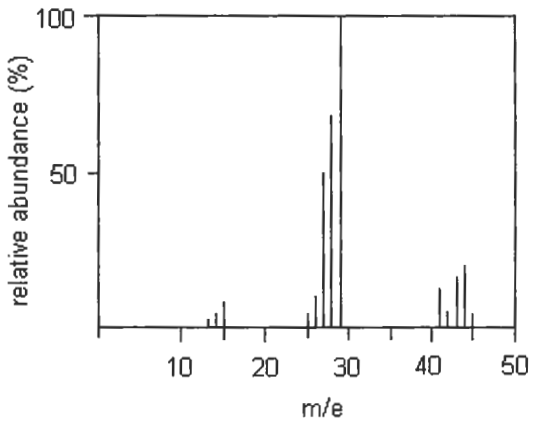
(ii) A typical mass spectrum of an organic compound is shown below.



Explain the presence of the large number of different peaks appearing in this spectrum. **2**

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End of paper

2008 CHEMISTRY HSC TRIAL – Mapping Grid

Question	Marks	Content	Target performance band
1	1	9.2.1	2-5
2	1	9.2.3	2-5
3	1	9.2.5	2-5
4	1	9.2.3	2-5
5	1	9.2.5	2-5
6	1	9.3.4	2-5
7	1	9.3.4	2-5
8	1	9.3.2	2-5
9	1	9.3.3	2-5
10	1	9.3.2	2-5
11	1	9.3.2	2-5
12	1	9.4.2	2-5
13	1	9.4.4	2-5
14	1	9.4.4	2-5
15	1	9.4.4	2-5
16(a)	1	9.2.1	3-4
16(b)	1	9.2.1	3-5
16(c)	1	9.2.1	4-5
16(d)	2	9.2.1	4
16(e)(i)	2	9.2.1 9.3.5	3-5
16(e)(ii)	2	9.2.1 9.3.5	4-5
17(a)	2	9.2.1 9.2.3	3-5
17(b)	2	9.2.3	4-5
17(c)	3	9.2.3	3-4
18(a)(i)	1	9.2.4	3-4
18(a)(ii)	1	9.2.4	3-4
18(a)(iii)	1	9.2.4	3-4
18(b)	1	9.2.4	3-4
18(c)	1	9.2.4	3
19(a)	2	9.2.4	3-5
19(b)	1	9.2.4	3-4
20(a)	1	9.3.2	2-4
20(b)	2	9.3.2	3-5
20(c)(i)	1	9.3.2	2-4
20(c)(ii)	1	9.3.2	2-3
20(d)	2	9.3.2	3-5

21(a)	2	9.3.4	4-5
21(b)	2	9.3.1 9.3.4	3-5
21(c)	2	9.3.4	2-4
21(d)	3	9.3.3	4-6
22(a)	1	9.3.4	2-3
22(b)	1	9.3.4	3-4
22(c)	1	9.3.4	3-5
22(d)	2	9.4.3	3-5
22(e)	2	9.4.3	2-4
23(a)	1	9.4.5	3-4
23(b)	3	9.4.5	4-5
23(c)	1	9.4.5	3
24(a)	2	9.4.5	3-5
24(b)	2	9.4.5	3-5
25(a)	2	9.4.2	3-5
25(b)	2	9.4.2	3-5
26 Industrial chemistry	25	9.5	2-6
27 Shipwrecks corrosion and conservation	25	9.6	2-6
28 The biochemistry of movement	25	9.7	2-6
29 The chemistry of art	25	9.8	2-6
30 Forensic chemistry	25	9.9	2-6