2009

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 – 16
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 – 26
Allow about 1 hour 45 minutes for this part

Section II – Pages 17 – 38
Total marks (25)
Attempt ONE question from Questions 27 – 31
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
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1. Which of the following *species* is the strongest reductant (reducing agent)?

   (A) Zn
   (B) Zn^{2+}
   (C) Ag
   (D) Ag^{+}

2. Neutron-rich radioisotopes, such as cobalt-60, are most likely to be produced in which of the following?

   (A) Particle accelerator
   (B) Cloud chamber
   (C) Nuclear reactor
   (D) Catalytic cracker

3. The molar heat of combustion of ethanol is 1367 kJ mol^{-1}.

   What *mass of ethanol* is required to heat 1.0 mole of water by 10 °C?

   (A) 136.7g
   (B) 46.0 g
   (C) 25.3 g
   (D) 0.025 g

4. Which of the following shows the named *polymers* correctly matched with their corresponding monomers?

	Polychloroethene	***Polystyrene***	***Cellulose***	***Polyethylene***
(A)	Vinyl chloride	Vinyl benzene	Glucose	Ethylene
(B)	Vinyl chloride	Glucose	Vinyl benzene	Ethylene
(C)	Glucose	Vinyl chloride	Vinyl benzene	Ethylene
(D)	Vinyl benzene	Ethylene	Glucose	Vinyl chloride

5. In the *lead-acid galvanic cell,* which statement describes the reaction at the anode?

   (A) Oxidation of lead to lead(IV) oxide
   (B) Oxidation of lead to lead(II) sulfate
   (C) Reduction of lead(IV) oxide to lead
   (D) Reduction of lead(IV) oxide to lead(II) sulfate

6. Each of the substances below is used to improve soil quality in crops. Which substance would act to *increase soil pH*?

   (A) Ammonium sulfate
   (B) Gypsum (hydrated calcium sulphate)
   (C) Superphosphate (calcium dihydrogen phosphate)
   (D) Ammonia gas

7. Which of the following combinations, of equal volumes of 1.00 mol L^{-1} solutions, would act as an acid-base *buffer*?

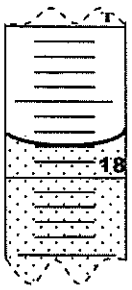
(A) Acetic acid and sodium hydroxide
(B) Sodium acetate and hydrochloric acid
(C) Acetic acid and sodium acetate
(D) Hydrochloric acid and sodium hydroxide

8. Rainwater has a pH of about 5, while seawater has a pH of about 8.

Which statement is correct concerning the *hydrogen ion concentrations* of rainwater and seawater?

(A) The hydrogen ion concentration in rainwater is greater by a factor of 1000.
(B) The hydrogen ion concentration in rainwater is greater by a factor of 3.
(C) The hydrogen ion concentration in rainwater is less by a factor of 1000.
(D) The hydrogen ion concentration in rainwater is less by a factor of 5/8.

9. The diagram below shows hydrochloric acid solution in a burette, at the end-point of a titration with an ammonia solution. The starting level of the acid was 0.0 mL.



Which statement about the *end-point* of the titration is correct?

(A) The acid volume used was 17.7 mL at pH = 7.
(B) The acid volume used was 17.8 mL at pH <7.
(C) The acid volume used was 18.2 mL at pH >7.
(D) The acid volume used was 18.25 mL at pH =7.

10. Borate ion assists in buffering seawater at a pH of about 8, in the following equilibrium:

$$H_3BO_3 + H_2O \leftrightarrow H_2BO_3^- + H_3O^+$$

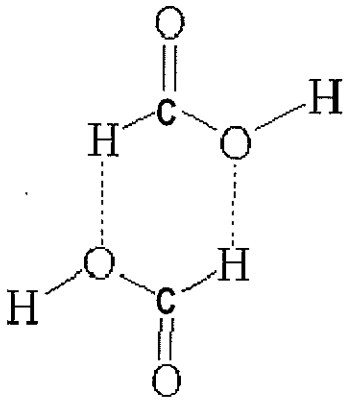
Which of the above species are *amphiprotic*?

(A) H_3BO_3 and H_2O
(B) H_2O and H_3O^+
(C) H_2O and $H_2BO_3^-$
(D) H_3BO_3 and H_3O^+

11. Each of the following substances is an atmospheric pollutant. Which substance would contribute directly to the formation of *acid rain*?

(A) Methane
(B) Ammonia
(C) Ozone
(D) Sulfur dioxide

12. In the gaseous state, formic acid exists as a dimer with the structure shown below:



Which bond type joins the two molecules?

(A) Normal covalent
(B) Polar covalent
(C) Coordinate covalent
(D) Hydrogen Bond

13. Methanol can be produced through the reaction of carbon monoxide with hydrogen, as shown below:

$$CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)} \quad \Delta H = -155 \text{ kJ mol}^{-1}$$

Which set of conditions would increase the *equilibrium yield* of methanol?

(A) High pressure and temperature
(B) Low pressure and temperature
(C) High pressure and low temperature
(D) Low pressure and high temperature

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — 79 Au — Symbol of element

Atomic Weight — 197.0 — Name of element

Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Chemistry

DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$\text{pH} = -\log_{10}[\text{H}^+] \qquad \Delta H = -mC\Delta T$$

Some standard potentials

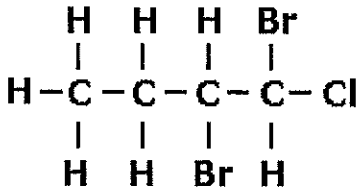
$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

14. Which of the following reagents would be most useful to separate *barium ions* from a solution which *also* contains *magnesium ions*?

(A) Dilute sulfuric acid
(B) Potassium chloride solution
(C) Sodium carbonate solution
(D) Ammonia solution

15. Observe the following structural diagram.



Which of the following is the *systematic name* for this compound?

(A) 3,4-dibromo-4-chlorobutane
(B) 1,2-dibromo-1-chlorobutane
(C) 2,1-dibromo-1-chlorobutane
(D) 4-chloro-3,4-dibromobutane

Section I (continued)

Part B
Total marks (60)
Attempt Questions 16 – 26
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 (7 marks) **Marks**

Most of the ethanol used in industry within Australia is produced from *ethylene*, from petroleum.

(a) Describe how ethylene is obtained from petroleum. **2**

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(b) Write an *equation* for the *production of ethanol* from ethylene, and identify the catalyst used. **2**

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(c) Explain how ethanol could be used as an alternative to petroleum, as a source of ethylene. **3**

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STUDENT NUMBER/NAME: .....

Question 17 (5 marks) **Marks**

Assess the use of *bromine water* for distinguishing between alkanes AND alkenes. **5**

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Question 18 (4 marks)

The element of atomic number 112 has now been added to the Periodic Table. With an atomic mass of about 277, it was first created by fusion of lead atoms with zinc ions. Element no. 112 has the proposed name 'Copernicium'.

(a) Describe how this combination is achieved, to create new heavy elements. **2**

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(b) Outline the value of research into new elements, such as element no. 112. **2**

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Question 19 (3 marks) **Marks**

Referring to *oxidation-reduction* reactions, explain the construction of a battery. **3**

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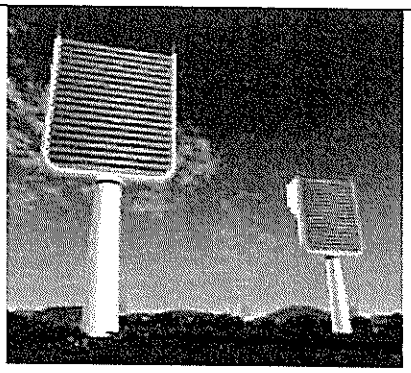
Question 20 (6 marks)

One suggested measure to remove carbon dioxide from the atmosphere is to construct "artificial trees" in which air passes through slats wet with dilute sodium hydroxide solution. The descending solution of sodium carbonate and water is collected and mixed with calcium hydroxide, precipitating calcium carbonate and regenerating sodium hydroxide for reuse.

Calcium carbonate is separated and heated to recover the carbon dioxide, for burial, and the calcium oxide recycled.



(a) Construct equations for the reaction of carbon dioxide with sodium hydroxide and the precipitation of calcium carbonate. **2**

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Question 20 continues on the next page

STUDENT NUMBER/NAME: .....

Question 20 (continued) **Marks**

(b) The atmospheric concentration of carbon dioxide is currently 380 ppm (0.038%) by volume.

Determine the volume of air, at 298.15 K and 100 kPa, which must pass through an "artificial tree" to deposit 1000 kg of calcium carbonate.
(Assume complete absorption of carbon dioxide) **2**

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(c) The main energy input in the above process is to decompose calcium carbonate, requiring 180 kJ mol^{-1}.

If the heat of combustion of natural gas is 1000 kJ mol^{-1}, determine the necessary volume of gas, at 298 K and 100 kPa, needed to provide the heat to decompose 1000 kg of calcium carbonate. **2**

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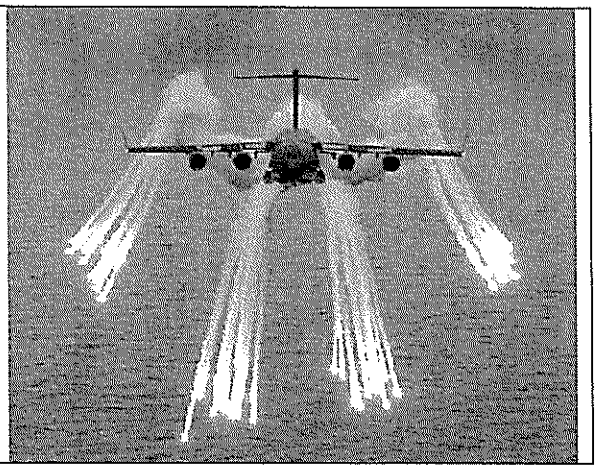
Question 21 and 22 refer to the following information.

Decoy flares are used by military aircraft to divert 'heat-seeking' missiles.

One type of flare ignites a mixture of powdered magnesium and polytetrafluoroethylene (teflon).

Great care has to be taken in handling the flares, to avoid accidental ignition by stray electrostatic charges.



$$2Mg_{(s)} + (-CF_2\text{-}CF_2\text{-})_n \rightarrow 2MgF_{2(s)} + 2C_{(s)} \quad \Delta H = -1438 \text{ kJ mol}^{-1}$$

Question 21 (4 marks) **Marks**

(a) Demonstrate that this is an *oxidation-reduction* reaction AND identify which element is reduced. **2**

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(b) Identify the advantages of using *polymeric Teflon,* in preference to the monomeric tetrafluoroethylene, in the above application. **2**

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Question 22 (8 marks)

To analyse a flare mixture for magnesium content, a 2.12 g sample is placed in 500 mL of 0.25 mol L^{-1} sulfuric acid solution. After all magnesium had been dissolved, the remaining solution was titrated with standard sodium hydroxide solution, using phenolphthalein indicator. The titration results are given below:

Concentration of standard NaOH = 0.220 mol L^{-1} (Volume NaOH used = 25.0 mL)

Start Point (mL)	**End Point (mL)**	**Vol H_2SO_4 (mL)**
0.0	18.6	
18.6	37.3	
12.8	31.5	
	Mean Volume:	

(a) **Complete the table** of *titration measurements* above. **1**

Question 22 continues on the next page

Question 22 (continued) **Marks**

(b) Determine the concentration of the titrating sulfuric acid solution. **2**

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(c) Determine the *mass* and *percentage of magnesium* in the flare mixture. **2**

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(d) Identify the *instrument* used to obtain 25.0 mL of sodium hydroxide solution. **1**

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(e) Outline an alternative method of determining the mass of magnesium in a sample, based on *gas volume*. **2**

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End of Question 22

Question 23 (5 marks) **Marks**

In early 2009 astronomers announced the discovery of molecules of ethyl formate (ethylmethanoate), in interstellar space. It was noted that this is the chemical giving raspberries their characteristic flavour.

The table compares properties of three related substances.

Substance:	Ethanol	Formic acid	Ethyl formate
Boiling point (°C)	78	101	54
Solubility in water	Soluble	Soluble	Soluble

(a) Provide a structural formula for ethyl formate. **1**

(b) Outline a procedure for making a sample of ethyl formate in the laboratory. **2**

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(c) Identify a compound, which is *not* an ester, that is isomeric with ethyl formate.

Describe an *observable property* in which the two compounds would differ. **2**

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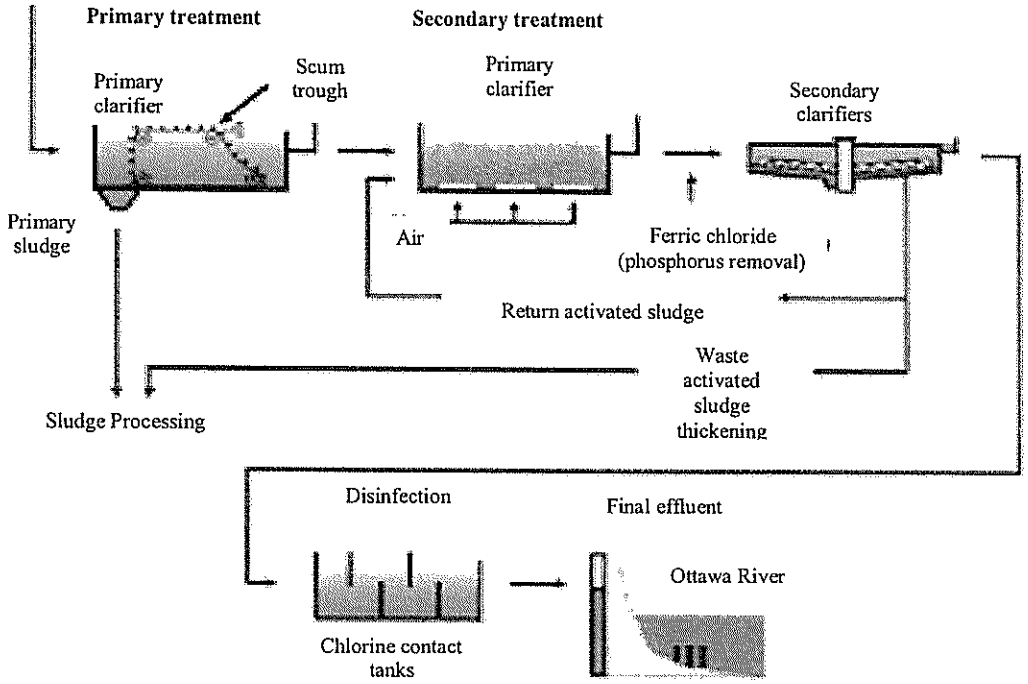
Question 24 and 25 refer to the diagram below of wastewater treatment for a town on the Ottawa River, in inland Canada.



Question 24 (7 marks)

(a) Construct an equation for the removal of phosphorus by iron(III) chloride, AND explain the importance of this process to the quality of the final effluent. **2**

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(b) Identify a chemical or process suitable for use in the disinfection tank AND explain how it works. **2**

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(c) With the aid of a *chemical equation*, outline a test procedure you would use to measure the chloride concentration in the final effluent. **3**

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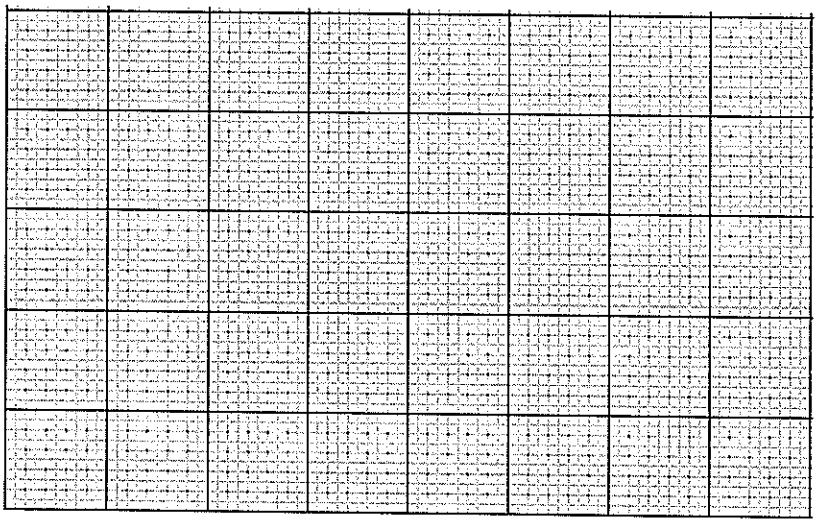
Question 25 (7 marks) **Marks**

In monitoring the effect of the discharge effluent on river water quality, a chemist uses *atomic absorption spectroscopy* to compare the sodium ion concentrations above and below the discharge point in the Ottawa River. The table below shows the absorbance values at a wavelength of 589 nm, for water samples, and also those for a range of standard solutions.

Solution	*Na^+ Concentration ($mg\ L^{-1}$)*	*Absorbance at 589 nm(%)*
Standard	10	16
Standard	20	34
Standard	40	63
Standard	60	98
Upriver sample 1		4
Upriver sample 2		5
Downriver Sample 1		54
Downriver sample 2		43

(a) Plot the 'Standards' on the grid below. (Label axes) **3**



(b) Complete the entries for *Na^+ concentration* of water samples **in the table above.** **2**

(c) Assess the downstream water quality for freshwater organisms, for which the maximum sodium ion concentration is 100 ppm. Explain why water quality might change in periods of low rainfall. **2**

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STUDENT NUMBER/NAME: .....

Question 26 (4 marks) **Marks**

(a) Using *Lewis electron dot* structures, compare the structures AND relative stabilities of molecular oxygen *and* the oxygen free radical. **2**

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(b) Using Lewis electron dot structures, demonstrate production of ozone in the stratosphere, AND identify the type of bonding involved. **2**

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End of Section I

Section II

Total marks (25)
Attempt ONE question from Questions 27 – 31
Allow about 45 minutes for this section

Show all relevant working in questions involving calculations.

STUDENT NUMBER/NAME: .....

Question 27 – Industrial Chemistry (25 marks) **Marks**

(a) Sodium hydroxide is one of the most important industrial chemicals, with annual use in Australia exceeding 1.3 million tonnes.

Discuss the production, properties and TWO uses of sodium hydroxide. Include all relevant chemical formulas and equations. 7

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Question 27 continues on the next page

Question 27 (continued) **Marks**

(b) A mixture of sulfur dioxide and oxygen reaches equilibrium at 700°C with the following concentrations (expressed as pressures):

Sulfur dioxide	223 kPa
Oxygen	114 kPa
Sulfur trioxide	626 kPa

(i) Determine the equilibrium constant (Kp) for the production of sulfur trioxide under these conditions. **2**

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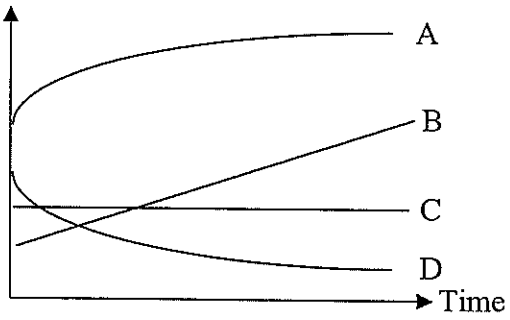
(ii) The total pressure of the mixture is rapidly reduced. **2**



Using the graphs above, fill in the table (with an A,B,C or D) choosing those which show how the system changes as equilibrium is restored.

Property	*Total pressure*	*Kp*	*Yield of SO_3*
Graph (A,B,C,orD)			

(iii) At 25° C the equilibrium constant is 2.6×10^{12}.

Explain why this is not a suitable temperature for the industrial production of sulfur dioxide. **1**

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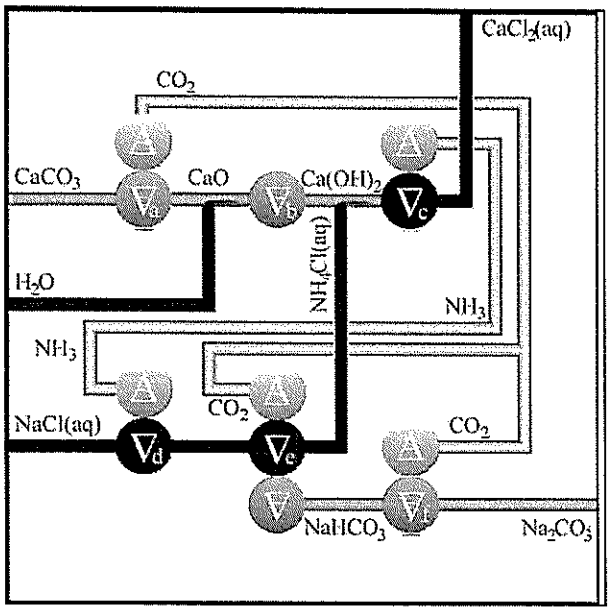
Question 26 continues on the next page

Question 27 (continued) **Marks**

(c) Refer to the flow chart diagram of the Solvay process.



(i) Write balanced equations for THREE endothermic reactions in this process. **3**

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(ii) Suggest a suitable fuel for the Solvay process, giving reasons for your choice. **2**

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Question 27 continues on the next page

Question 27 (continued) **Marks**

(d) Relate the structure of soap to its ability to form an emulsion in water and to dissolve grease. **4**

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(e) Using examples from your firsthand observations, describe the difference between a galvanic cell and an electrolytic cell. **4**

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End of Question 27

STUDENT NUMBER/NAME: .....

Question 28 – Shipwrecks, Corrosion and Conservation (25 marks) **Marks**

(a) With reference to the redox table explain the essential problem of protecting steel-hulled ships in a marine environment.

In your answer, identify measures taken to combat corrosion. Include relevant chemical formulas and equations. 7

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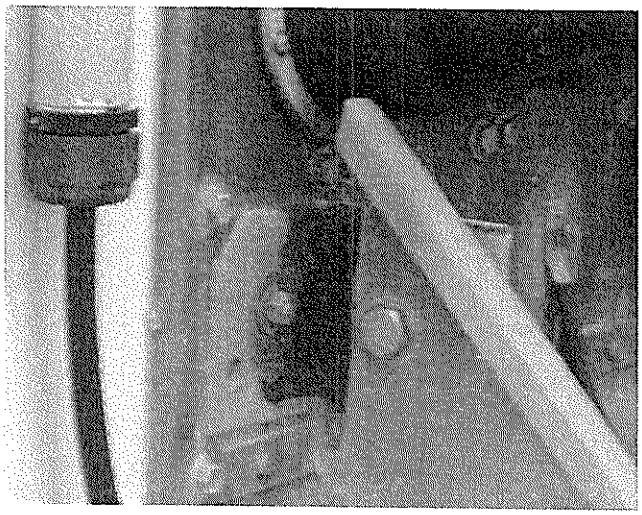
Question 28 continues on the next page

Question 28 (continued) Marks

(b) The photograph below shows a zinc-coated steel bracket, bolted to a copper earthing plate, in a seaside location.



(i) Explain the rapid corrosion of the galvanised steel under these conditions. 3

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(ii) Propose a material suitable for replacing the bracket, giving reasons for your choice. 2

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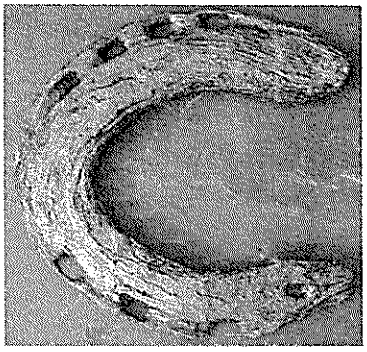
Question 28 continues on the next page

Question 28 (continued) **Marks**

(c) The photographs below show an iron horseshoe before and after restoration using electrolysis in a sodium carbonate solution.



(i) Construct a diagram of an electrolytic cell for this restoration, showing polarity, anode and cathode. **2**

(ii) Construct ionic equations for the half-cell reactions in this cell. **2**

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(iii) Electrolysis is continued until abundant gas bubbles are produced on the horseshoe surface.

Identify this gas and explain why it indicates that electrolytic restoration is complete. **1**

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Question 28 continues on the next page

Question 28 (continued) **Marks**

(d) Describe a first-hand investigation you have carried out to demonstrate the principle of cathodic protection. **4**

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(e) Describe how the work of Volta and Faraday increased our understanding of electron transfer reactions. **4**

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End of Question 28

STUDENT NUMBER/NAME: .....

Question 29 – The Biochemistry of Movement (25 marks) **Marks**

(a) Describe the formation and importance of glycogen.

Draw the structure of *glucose* and *glycogen* to illustrate your answer. 7

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Question 29 continues on the next page

Question 29 (continued) **Marks**

(b) Using an example, describe the relationship between the chemical features of a protein and its shape. **5**

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(c) Outline the ATP production involved in high intensity exercise, such as sprinting. **3**

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Question 29 continues on the next page

Question 29 (continued) **Marks**

(d) Outline the role of oxygen in respiration. **3**

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(e) Describe the process of muscle contraction. **5**

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Question 29 continues on the next page

Question 29 (continued) **Marks**

(f) Referring to NADH and $FADH_2$, construct equations to summarise the reduction/oxidation process in ATP regeneration. **2**

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End of Question 29

STUDENT NUMBER/NAME: .....

Question 30 – Chemistry of Art (25 marks) **Marks**

(a) Describe the principal features and limitations of the Bohr model of the atom and discuss how measurements of emission spectra and ionisation energies have led to more elaborate models.

Demonstrate the relationship of these models to the main blocks of the Periodic Table. 7

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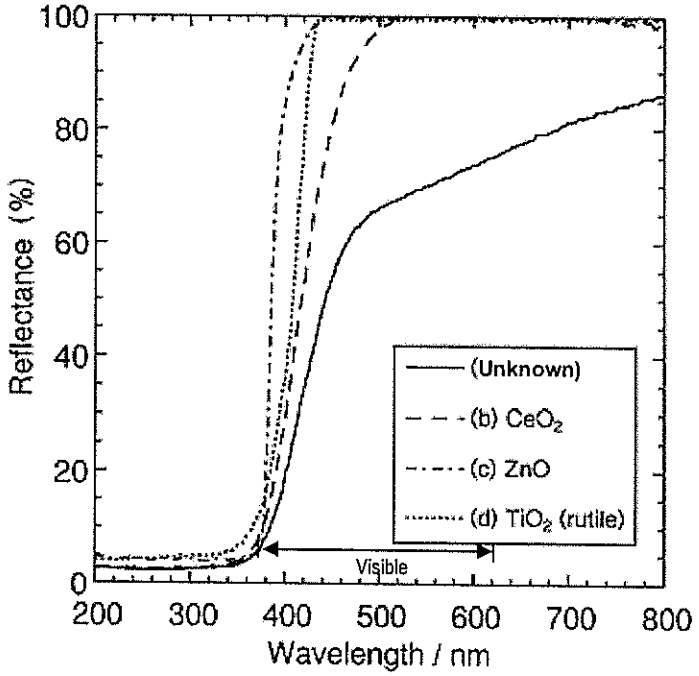
Question 30 continues on the next page

Question 30 (continued) **Marks**

(b) The graphs show the reflectance spectra of some powdered metal oxide pigments. The range of visible wavelengths is also indicated on the graph.



(i) Outline the predicted colour, in reflected light, of the unknown pigment. **2**

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(ii) Referring to the graphs, explain the use of titanium oxide as a pigment in paint, and of zinc oxide in sunscreen lotions. **2**

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(iii) Damaging UVA solar radiation has a wavelength range of 320-400 nm.

Assess the effectiveness of the pigments on the graph, in protecting the skin against UVA **1**

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Question 30 continues on the next page

Question 30 (continued) **Marks**

(c) Describe the use of laser microspectral analysis in comparing and matching pigment samples such as small paint chips. **5**

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Question 30 continues on the next page

Question 30 (continued) **Marks**

(d) *"Bluestone" is the common name for hydrated copper sulfate. When heated it forms colourless anhydrous copper sulfate. Dissolved in water and treated with concentrated hydrochloric acid it forms the green tetrachlorocopper(II) ion.*

Detail the electronic structure of the copper (II) ion and, with the aid of suitable diagrams, demonstrate the different bonding arrangements that lead to this range of colours based on the copper (II) ion. **4**

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Question 30 continues on the next page

Question 30 (continued) **Marks**

(e) Using some identified examples, outline the use of coloured pigments in paints.

Explain why some historical pigments are no longer in use. **4**

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End of Question 30

STUDENT NUMBER/NAME: .....

Question 31 – Forensic Chemistry (25 marks) **Marks**

(a) Outline the principles of atomic emission spectroscopy and evaluate its use in identifying the origin of soil samples. 7

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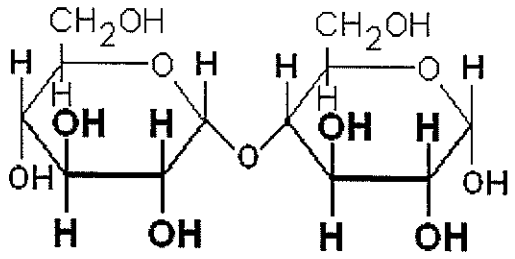
Question 31 continues on the next page

Question 31 (continued) **Marks**

(b) The structure of the sugar known as maltose is shown below.



(i) Explain why maltose is classified as a *carbohydrate*. **1**

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(ii) State whether maltose is a *reducing* or *non-reducing sugar*. Justify your answer. **2**

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(iii) Outline the relationship between sugars and starch. **2**

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(c) (i) Construct a general structural formula for amino acids. **1**

Question 31 continues on the next page

Question 31 (continued) **Marks**

(c) (ii) Assess the use of *electrophoresis* in identifying the composition of a mixture of amino acids. **4**

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(d) (i) Using equations, explain how an alkanol can be distinguished from a hydrocarbon. **2**

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(ii) Using equations, explain how an *organic compound* can be distinguished from an *inorganic compound*. **2**

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Question 31 continues on the next page

Question 31 (continued) Marks

(e) Outline the principles behind DNA analysis and explain why this analysis allows identification of individuals. **4**

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