Section I
75 marks

Part A – 15 marks
Attempt Questions 1-15
Allow about 30 minutes for this part

Use the multiple-choice answer sheet.

Select the alternative A,B,C or D that best answers the question.

1. A chemist observed a colour change after adding bromine water, $Br_2(aq)$, to an unknown hydrocarbon.

Which one of the following substances could she have produced in this reaction?

(A) pentane

(B) 2-pentene

(C) 1,3-dibromopentane

(D) 2,3-dibromopentane

2. Which of the following correctly identifies the systematic name of the monomer that forms the polymer known as PVC?

(A) chloroethene

(B) vinyl chloride

(C) chloroethane

(D) polyvinylchloride

3. 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) Catalytic cracker

(D) Nuclear reactor

4. Which one of the following species is the strongest oxidising agent?

(A) Na^+

(B) Na

(C) F^-

(D) F_2

5. 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

6. This question refers to the following substances:

i. H_2CO_3
ii. NH_4Cl
iii. $NaCH_3COO$
iv. CH_3COOH

Solutions of which of the substances listed would be acidic?

(A) (i) only

(B) (i) and (iv)

(C) (i), (ii) and (iv)

(D) (i), (iii) and (iv)

7. Which of the following may indicate a fresh water sample has a high degree of hardness?

(A) A lower than normal pH.

(B) A lower than normal BOD.

(C) A higher than normal electrical conductivity.

(D) A higher than normal turbidity.

8. Energy content per kg is an important consideration for bushwalkers carrying liquid fuels.

Which one of the following fuels releases the most energy per kg when it undergoes complete combustion?

Alkanol	Molar mass	Heat of combustion (kJ/mol)
ethanol	46.1	1364
butane	58.1	2877
1-propanol	60.1	2021
hexane	86.2	4163

(A) ethanol

(B) butane

(C) 1-propanol

(D) hexane

9. 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 in concentration in rainwater is greater by a factor of 1000.

(B) The hydrogen in concentration in rainwater is greater by a factor of 3.

(C) The hydrogen in concentration in rainwater is less by a factor of 1000.

(D) The hydrogen in concentration in rainwater is less by a factor of 5/8.

10. Borate ion (BO_3^{3-}) assists in buffering seawater at a pH of about 8, in the following equilibrium:

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

Which of the above species are *amphiprotic*?

(A) H_3BO_3 and H_2O

(B) H_2O and $H_2BO_3^-$

(C) H_2O and H_3O^+

(D) H_3BO_3 and $H_2BO_3^-$

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

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

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

(A) Low pressure and high temperature

(B) High pressure and low temperature

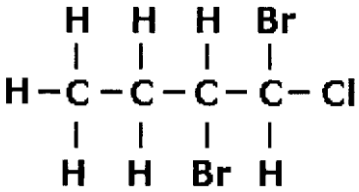
(C) Low pressure and temperature

(D) High temperature and pressure

12. Which of the following correctly matches the name of the scientist with the theory on the nature of acids they proposed?

	Scientist	**Theory of the nature of acids**
(A)	Arrhenius	Acids produce H^+ ions in solution.
(B)	Bronsted	Acids accept protons.
(C)	Davy	Acids contain oxygen.
(D)	Lavoisier	Acids contain hydrogen.

13. 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) 1-chloro-1,2-dibromobutane

(D) 4-chloro-3,4-dibromobutane

14. Which one of the following is used as a catalyst in the dehydration of ethanol?

(A) concentrated H_2SO_4

(B) dilute H_2SO_4

(C) concentrated HCl

(D) dilute HCl

15. A chemistry class was asked to determine the % of sulfate in lawn fertiliser. According to the packet, the fertiliser contained 36% sulfate by mass.

Each student weighed out 2.00 g of the lawn fertilizer and dissolved it in dilute nitric acid. They added excess 2M barium nitrate solution and noted that a white precipitate formed. They then followed slightly different techniques to obtain dry samples of barium sulfate, which they weighed carefully. Each student repeated the investigation 3 times. Their results are shown below.

Student	Mass of ppt (g)			
	TRIAL 1	TRIAL 2	TRIAL 3	Average
1	1.12	1.56	1.30	1.33
2	1.87	1.80	1.72	1.80
3	1.75	2.15	1.46	1.79
4	1.35	1.40	1.45	1.40

Which student's results could be described as being the most accurate and reliable?

(A) Student 1.

(B) Student 2.

(C) Student 3.

(D) Student 4.

Student Number: …….

Part B
Attempt questions 16 – 28
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Marks

Question 16 (3 marks)

Most of the ethanol used in industry within Australia is produced from *ethylene*, which is derived from petroleum. **3**

Explain how ethanol could be used as an alternative to petroleum, as a source of ethylene.

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Question 17 (4 marks)

7.50 g of a pure, monoprotic alkanoic acid (represented as HX) is reacted with excess Na_2CO_3 producing 2.02 L of dry carbon dioxide gas, measured at 25^oC and 100 kPa pressure.

(a) Calculate the moles of carbon dioxide gas released by this reaction. **1**

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(b) Use your answer to (a) to calculate the molar mass of the alkanoic acid. **2**

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(c) Another monoprotic alkanoic acid is propanoic acid. Draw the structural formula of propanoic acid. **1**

Student Number: ……

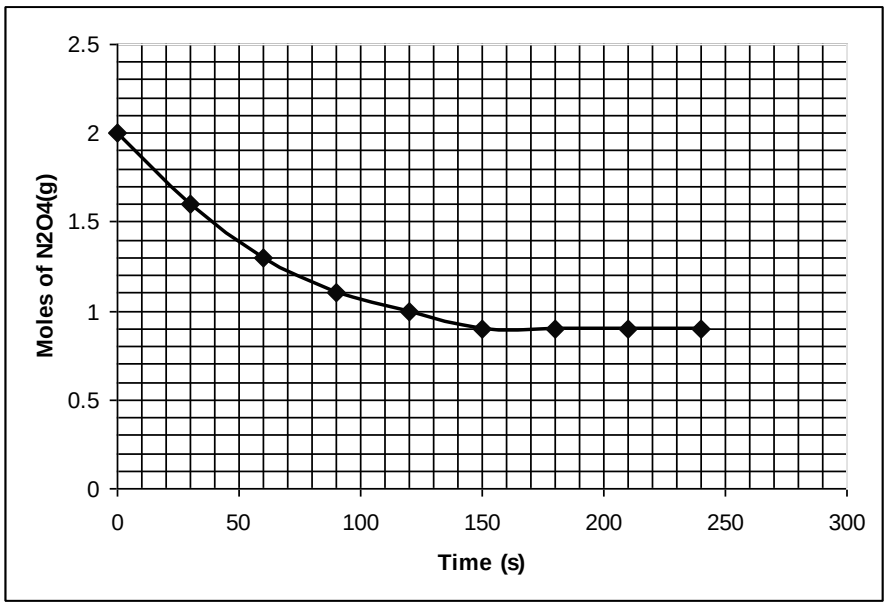
Marks

Question 18 (5 marks)

Colourless dinitrogen tetroxide decomposes to brown nitrogen dioxide according to the following equation:

$$N_2O_4(g) \longleftrightarrow 2NO_2(g)$$

The graph below shows how the moles of N_2O_4 (g) in a 1 L sealed flask changes over time.



(a) At what time did the system come to a state of equilibrium? Provide a chemical justification of your answer. **2**

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(b) Identify how an observer of the flask may infer the system has reached a state of equilibrium. **1**

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(c) Use the data in the graph to determine the moles of nitrogen dioxide which would be present when the system is at equilibrium. **2**

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Marks

Question 19 (7 marks)

In May 2009, an estimated 4000 Brisbane homes were supplied with water with unacceptably high levels of the fluoride ion. The water they were supplied with contained up to 31 mg/L of fluoride instead of the maximum allowable 1.5 mg/L. The high fluoride levels were due to an error made at a water treatment plant, which was not detected until after the release of the water. Fluoride poisoning may result in a number of adverse health effects, including extreme nausea.

(a) Given that high levels of fluoride can result in adverse health effects, account for addition of fluoride to the mass water supply. **1**

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(b) Calculate the moles of fluoride ion present in a 250 mL glass of water containing the maximum acceptable levels of fluoride. **2**

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(c) Accidents such as the one described above illustrate the need for careful monitoring of the quality of the mass water supply. Describe TWO other tests which must be carried out on water prior to its release for public consumption and justify the need for each test. **4**

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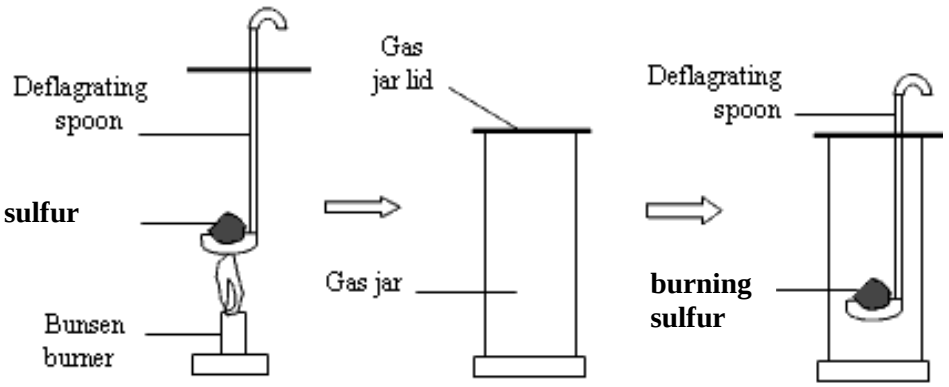
Marks

Question 20 (4 marks)

A chemistry teacher carried out the following demonstration.

A small mass of sulfur was combusted a in a spoon, burning with a blue flame. Whilst alight, it was placed into a gas jar to collect the gas produced.



A mist of water was sprayed into the gas jar. Some of the water which fell to the bottom of the jar was collected and tested with universal indicator. The indicator turned red.

Evaluate the above demonstration as a model for the formation of environmental acid rain. Include relevant balanced equations in your answer. **4**

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Question 21 (5 marks) **Marks**

In early 2009 astronomers announced the discovery of molecules of ethyl methanoate, 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	Methanoic acid	Ethyl methanoate
Boiling point (°C)	78	101	54
Solubility in water	Soluble	Soluble	Soluble

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

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

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(c) Identify a compound, which is *not* an ester, that is an isomer of ethyl methanoate and describe an *observable property* in which the two compounds would differ. **2**

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Student Number: …….

Question 22 (6 marks) **Marks**

(a) Provide a description of Le Chatelier's Principle. **1**

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(b) Assess the significance of this principle to the work carried out by Haber in his efforts to industrially produce ammonia. **5**

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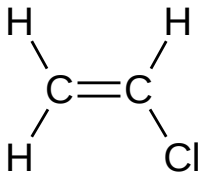
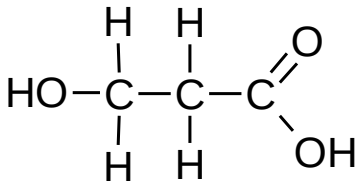
Question 23 (5 marks) **Marks**

The table below shows the structural formula of two monomers, labelled A and B.

Monomer	Structural formula
A	
B	

Compare the polymerisation reactions of monomers A and B. Use appropriate equations to support your answer. **5**

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Question 24 (7 marks) **Marks**

(a) Draw the Lewis electron dot diagrams for molecular oxygen and ozone. **1**

(b) Compare the structure and reactivity of these allotropes of oxygen. **2**

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(c) Write the equation for the production of ozone in the stratosphere. **1**

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(d) Compare the impact of ozone concentration at ground level and in the stratosphere. **3**

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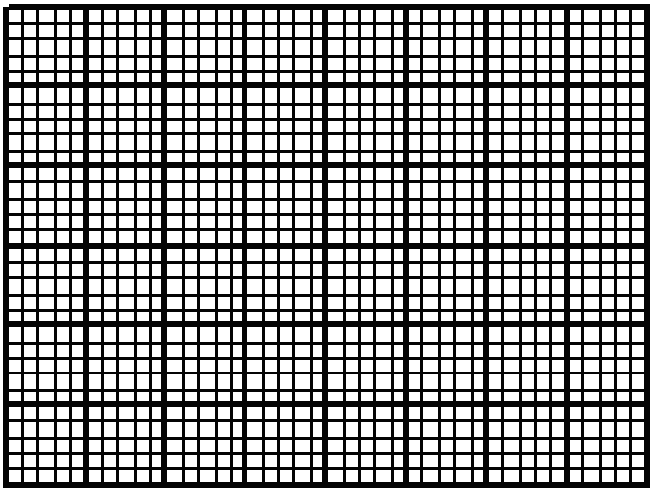
Question 25 (5 marks) **Marks**

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, of 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		4
Downriver Sample		54

(a) Plot the 'Standards on the grid below. (Label axes). **2**



(b) Complete the entries for *Na^+ Concentration* of water samples **in the table above.** **1**

(c) Assess the downstream water quality for freshwater organisms, for which the maximum sodium ion concentration is 100 ppm. **2**

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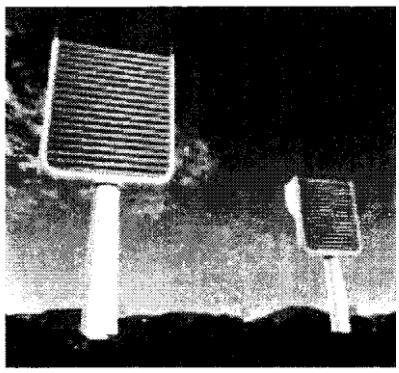
Student Number: …….

Question 26 (3 marks) **Marks**



One suggested method 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 missed 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 an equation for the reaction of carbon dioxide with sodium hydroxide. **1**

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b) The main energy input in the above process is to decompose calcium carbonate, requiring 180 kJ mol^{-1}. **2**

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.

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Marks

Question 27 (3 marks)

250 mL of a 0.15 mol L^{-1} solution of sodium hydroxide is added to a 175 mL solution of 0.08 mol L^{-1} sulfuric acid.

Calculate the pH of the resulting solution. Show all working. **3**

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Question 28 (3 marks)

Referring to *oxidation-reduction* reactions, explain the structure AND chemistry of either the dry-cell OR lead-acid cell. **3**

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Student Number: …….

Section II
Total marks: 25
Allow about 45 minutes for this Section.

Answer the questions in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Marks

Question 29 - Shipwrecks, Corrosion and Conservation (25 marks)

(a) Identify TWO sources of minerals in oceans. **2**

(b) Oxidation-reduction (or redox) reactions, are the basis of many industrial and biological processes.

(i) Outline the major features in the operation of a galvanic cell. **2**

(ii) Discuss the contribution of Volta and Davy in increasing our understanding of electron transfer reactions and its applications. **4**

(c) Explain the difference in concentration of dissolved oxygen AND carbon dioxide at the surface of the ocean AND at a depth of 1000 m. **4**

(d) Understanding the chemistry of metals and alloys is essential for using and protecting them appropriately.

(i) A mild steel bracket has been bolted to a copper earthing plate in a seaside location. Explain the rapid corrosion of the steel under these conditions. **3**

(ii) Aluminium is a more active metal than iron, yet it is commonly used for window frames. Explain this statement. **2**

(iii) Explain how the composition of various types of steel affects their use. Include specific examples in your answer. **4**

(e) (i) Define the term *corrosion.* **1**

(ii) Explain the process of rusting. Include chemical equations in your answer. **3**

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

$\mathrm{pH} = -\log_{10}[\mathrm{H}^+]$ $\qquad\qquad$ $\Delta H = -m\,C\,\Delta T$

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.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — Symbol of element — Atomic Weight — Name of element

Example: 79 Au 197.0 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 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 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 [98.91] 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 [210.0] 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 [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] 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 [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] 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.

Strathfield Girls High School

2009 Year 12 Trial Examination

Part A – Multiple choice

Answer sheet

Student Number _____

	A	B	C	D
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HSC CHEMISTRY 2009
Trial HSC Examination

Marking scheme and sample answers

Multiple Choice

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answer	D	A	D	D	C	C	C	B	A	B	B	A	B	A	B

SECTION II – OPTION 9.6

Question 29 – Shipwrecks, Corrosion and Conservation

(a)

Marking Criteria	Marks
Identifies TWO sources of minerals in oceans	2
Identifies one source of minerals in oceans	1

Sample Answer

Sources of minerals in oceans include-

- Rainwater falling onto land (terrestrial environments) that penetrates through rocks and soil and leaches out soluble minerals.
- Hydrothermal vents in mid-ocean ridges.
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(b) (i)

Marking Criteria	Marks
Outlines all major features of a galvanic cell – oxidation half cell, reduction half cell, salt bridge and external circuit	2
Outlines some of the major features of a galvanic cell	1

Sample Answer

A galvanic cell must have two half cells which are linked by a metallic conductor to allow electron transfer and a salt bridge to allow ion transfer. One half cell is the oxidation half cell and the other is the reduction half cell. Each half cell must have an electrode, which is a conductor of electrons such as a metal or carbon, and an electrolyte which contains mobile ions. When a galvanic cell operates, electrons are transferred from the oxidation half cell to the reduction half cell through the metallic conductor.

(b) (ii)

Marking Criteria	Marks
Describes the work of Volta and Davy and indicates their contribution to our understanding of electron transfer reactions.	3 – 4
Describes the work of Volta OR Davy OR outlines the work of both Volta and Davy	2
Outlines the work of Volta OR Davy	1

Volta's main contribution was the construction of a useable galvanic cell – the first source of direct electric current. He showed that if two different metals, silver and zinc, were bought into contact in a salt solution an electric current was generated. He later obtained much larger currents from his Voltaic pile. This device was made of a vertical pile of alternating disks of zinc and silver, with each pair of disks separated by cardboard soaked in a concentrated salt solution called brine. Attaching a wire to the ends of the Pile produced an electric current.
Davy's major contribution was to use the Voltaic pile to electrolyse many compounds and so decompose them. He also coined the term 'electrochemistry' which we use today.
Davy developed improved versions of Volta's pile and used them to pass strong electric currents through molten salts, such as potash (potassium hydroxide) and soda (sodium hydroxide), that were suspected of containing undiscovered elements. In this way he isolated the new elements potassium, sodium, barium, calcium, strontium and magnesium.

(c)

Marking Criteria	Marks
Explains the difference in the concentration of oxygen and carbon dioxide at the surface and at a depth of 1000 m by referring to the effects of the processes of dissolution, photosynthesis and respiration at each depth.	3 - 4
Explains the difference in the concentration of oxygen at the surface and at a depth of 1000 m by referring to the effects of the processes of dissolution, photosynthesis and the penetration of light, respiration and decomposition at each depth **OR** Explains the difference in the concentration of carbon dioxide at the surface and at a depth of 1000 m by referring to the effects of the processes of dissolution, respiration and decomposition at each depth.	1 - 2

Sample Answer
Ocean water near the surface is generally saturated with oxygen and carbon dioxide as there is good stirring of both the water and the atmosphere near the surface facilitating the dissolution of these gases. As well as being dissolved directly from the atmosphere, oxygen is produced in the surface waters by the photosynthetic process of phytoplankton.

Oxygen concentration generally decreases with increasing depth. This is because production of oxygen by photosynthetic organisms occurs only in the top 100 m as light cannot penetrate further. Also oxygen is continually consumed by organisms such as fish and aerobic bacteria. Thus at depths of 1000 m respiration processes of marine organisms as well as of decomposition dominate and oxygen levels fall. Thus oxygen concentrations at 1000 m are typically around 0.5 ppm.

Carbon dioxide concentrations increase with increasing depth. At a depth of 1000 m carbon dioxide gas is continually being generated by organisms through respiration and decomposition of organic matter, however, it is not being removed as no photosynthesis occurs at great depths.

(d) (i)

Marking Criteria	Marks
Explains how the presence of a less active metal AND a more conductive electrolyte accelerate corrosion.	3
Explains how the presence of a less active metal accelerates corrosion OR explains how a more conductive electrolyte accelerates corrosion.	2
Identifies that contact with a less active metal accelerates corrosion OR Identifies that the presence of ions in the moisture layer accelerates corrosion.	1

Sample Answer
Contact with a less active metal will accelerate the rate at which rusting occurs. The less reactive metal acts as a cathode, a site for reduction, and so makes it easier for electrons to be transferred to the oxygen so that the reactive metal is oxidised more rapidly.
Also the presence of sodium and chloride ions provides a more conductive electrolyte than water to allow ion migration and faster charge movement thus increasing the rate of corrosion.

(d) (ii)

Marking Criteria	Marks
Explains the passivating behaviour of aluminium in terms of the type of oxide layer formed compared to the oxide layer formed by iron.	2
Identifies aluminium as a passivating metal.	1

Sample Answer
Aluminium is a more active metal than iron. When aluminium is exposed to the air, it rapidly forms an oxide layer on the metal surface. Unlike rust, the oxide layer formed when iron is exposed to the air, the thin layer of aluminium oxide is tightly bonded to the metal and is non-porous so oxygen and water cannot penetrate to the aluminium metal beneath. Consequently, corrosion of the aluminium does not continue and the aluminium is protected by its own oxide layer and so can be used as window frames.

(d) (iii)

Marking criteria	Marks
Provides a detailed explanation of how the composition of steel affects its use in terms of its properties for at least TWO identified types of steel.	3 - 4
Explains how the composition of one identified type of steel affects its use in terms of its properties. Identifies one alloying metal in steel and describes how it affects the use of the steel in terms of its properties.	2
Correctly identifies the composition of an identified type of steel OR states the effect on a property of steel due to an added element	1

Sample answer
All steel is an alloy of iron and a small amount of carbon. As steel is a mixture, adding different elements to the steel will produce steels with particular properties for certain applications as the steel takes on the properties of the added elements.
Mild steel has < 0.2% carbon and is soft and malleable and it can be easily welded and so it is used in car bodies and to make ship hulls. However, structural steel has 0.2 – 0.5 % carbon. Increasing the carbon content of the steel increases its hardness and tensile strength and so it is used as girders and beams in buildings and as reinforcing for buildings where high tensile strength is necessary.
Stainless steel contains about 10 - 20 % chromium and about 10% nickel. Alloying steel with chromium produces a passive oxide layer on the surface of the steel which makes it very resistant to corrosion. The presence of nickel improves the steel's tensile strength and hardness. Thus stainless steel can be used for cutlery, kitchen sinks and dental instruments as it is hard and takes a high polish and is resistant to chemicals in food such as acids.

(e) (i)

Criteria	Marks
Any correct definition of corrosion	1

Sample answer

Corrosion is the degradation (or eating away) of a metal due to the oxidation of the metal by substances in the environment so that it loses its strength and properties and is unable to perform its intended purpose.

(e) (ii)

Marking Criteria	Marks
Outlines the reactions at the anode and cathode, supported by <u>correct</u> chemical equations. Describes the migration of Fe^{2+} ions and OH^- ions in the electrolyte and the formation of $Fe(OH)_{2\,(s)}$. Outlines the formation of rust as hydrated iron (III) oxide.	3
Describes the reactions at the anode and cathode, supported by a <u>correct</u> chemical equation for one and describes the migration of the ions. **OR** Describes the reactions at the anode and cathode, formation of $Fe(OH)_{2\,(s)}$ and the formation of rust as hydrated iron (III) oxide.	2
Outlines the reactions at the anode (oxidation of iron) and cathode (reduction of oxygen). **OR** Outlines the rusting process as an electrochemical process involving oxidation, reduction and the migration of ions.	1

Sample answer

Rusting of iron occurs when oxygen and water are present. In the process of rusting a galvanic cell is set up. An anode site occurs where the iron is under stress such as at bends. At the anode, the iron is oxidised to form iron (II) ions.

Anode reaction: $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$

The electrons produced at the anode flow through the iron to a cathode site. This occurs where an impurity such as carbon is located. At the cathode, reduction of oxygen occurs to produce hydroxide ions.

Cathode reaction: $O_{2\,(aq)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$

The moisture layer (water) allows for the migration of the ions (cations to cathode and anions towards anode) to maintain electrical neutrality, so the Fe^{2+} and OH^- ions move towards each other and react to form insoluble iron (II) hydroxide.

Equation: $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_{2\,(s)}$

Finally, iron (II) hydroxide reacts with oxygen to form rust (hydrated iron (III) oxide).

Equation: $2Fe(OH)_{2\,(s)} + {}^1/_2\,O_2 \rightarrow Fe_2O_3.H_2O + H_2O$