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: .....

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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*?

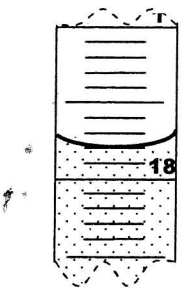
(A) Acetic acid and sodium hydroxide
(B) Sodium acetate and hydrochloric acid
(C) Acetic acid and sodium acetate
(D) Hydrochloric acid and sodium hydroxide

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:

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

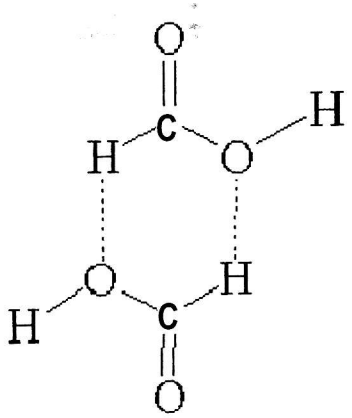
Which of the above species are *amphiprotic*?

(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:

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

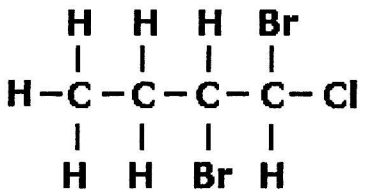
Which set of conditions would increase the *equilibrium yield* of methanol?

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

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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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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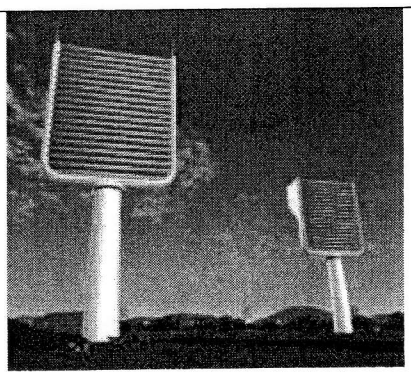
Question 20 (6 marks)

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

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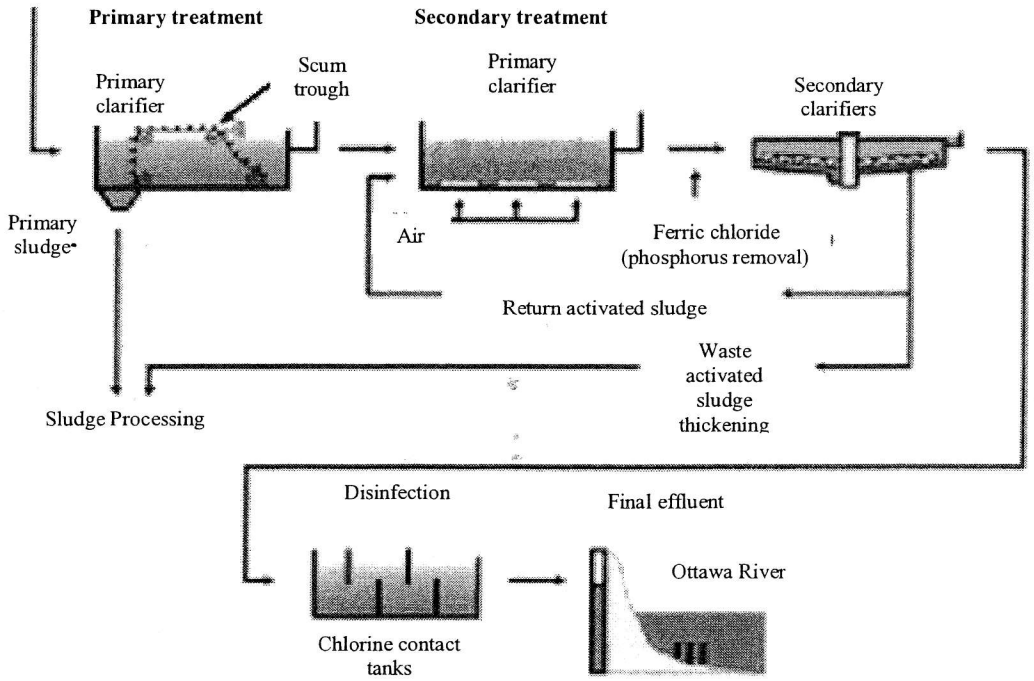
Question 24 and 25 refer to the diagram below of wastewater treatment for a town on the Ottawa River, in inland Canada.



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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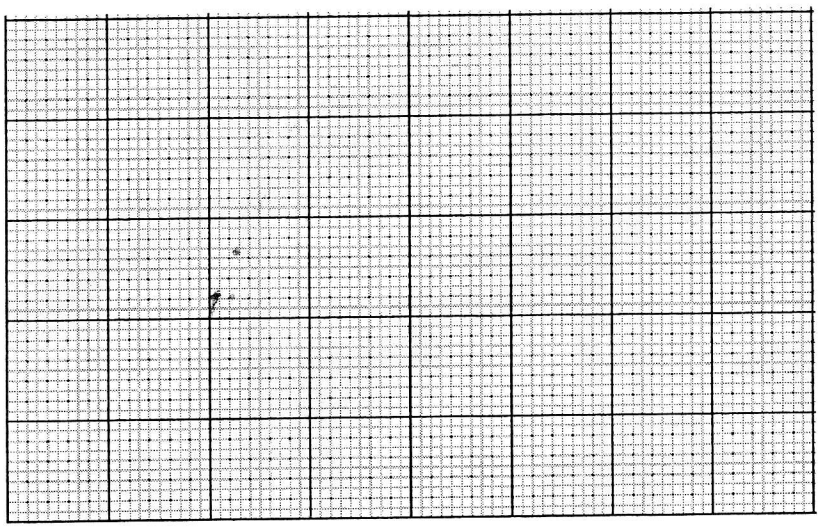
Question 25 (7 marks) **Marks**

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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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

STUDENT NUMBER/NAME: .....

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

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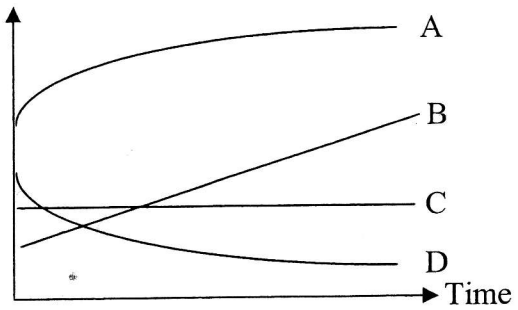
(ii) The total pressure of the mixture is rapidly reduced. **2**



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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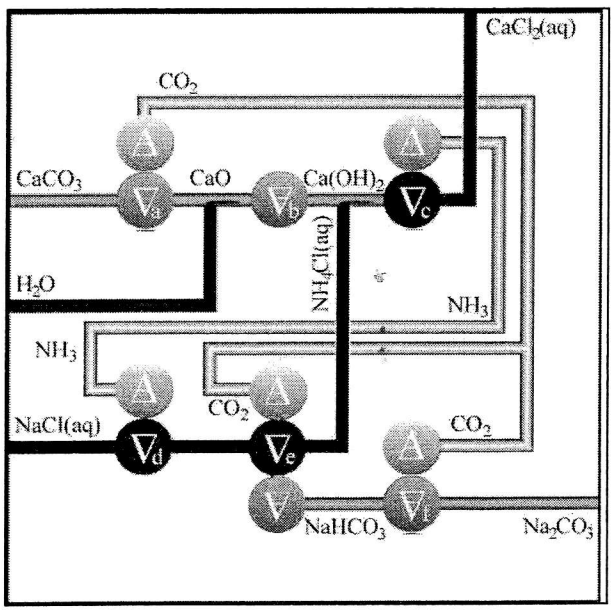
Question 26 continues on the next page

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