SYDNEY GRAMMAR SCHOOL

2010
FORM VI
TRIAL HSC EXAMINATION

Chemistry

Tuesday 10th August 8.40 am

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your candidate number and master's initials at the top of each page in Part B and on the answer booklet

CHECKLIST	
Each boy should have the following :	
1 Question Paper	
1 Multiple Choice Answer Sheet	
1 5 - Page Booklet	

Chemistry Classes.

1 TW	2 MTK	3 JAG	
4 JAG	5 EJS	6 AKBB	7 MRB

Section I Pages 2 - 20

Total marks (100)

This section has two parts, Part A and Part B

Part A
Total marks **(20)**
- Attempt Questions 1-20
- Allow about 30 minutes for this Section

Part B
Total marks **(55)**
- Attempt Questions 21-33
- Allow about 1 hour and 45 minutes for this Section

Section II   Pages 21-24
Total marks **(25)**
- Attempt Question 34 in this section.
- Allow about 45 minutes for this Section

EXAMINERS: JAG / MTK / MRB / TW

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Part A
Total marks (20)
Attempt Questions 1-20
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. Fill the response circle completely.

Sample   2 + 4 =

(A) 2   (B) 6   (C) 8   (D) 9

◯ A   ⬤ B   ◯ C   ◯ D

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

⬤ A   ⊗ B   ◯ C   ◯ D

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.

correct

⊗ A   ⊗ B   ◯ C   ◯ D

1   Which chemist first proposed the theory that acids contain oxygen?

(A)   Arrhenius
(B)   Lavoisier
(C)   Brønsted
(D)   Davy

2   Why can ethanol be called a renewable resource?

(A)   It can be distilled from recycled polyethylene.
(B)   The conversion of ethene to ethanol is a reversible process.
(C)   It can be produced from biomass.
(D)   Waste ethanol solvent can be reused as a fuel.

3   What is the name of the following compound?
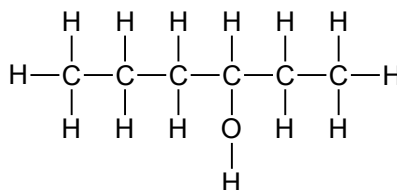
(A)   Hexan-3-ol
(B)   Heptan-3-ol
(C)   Hexan-4-ol
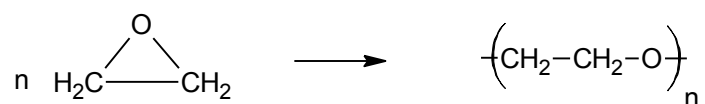(D)   Octan-5-ol

4   Which of the following ions can be readily identified using a flame test?

(A) Fe^{2+}
(B) Ca^{2+}
(C) NO_3^-
(D) Cl^-

5   25 mL of a solution of H_2SO_4 that has a pH of 3 is pipetted into a 250 mL volumetric flask and deionised water is added up to the mark. What is the final pH of the solution?

(A)   2
(B)   3
(C)   3.3
(D)   4

6   Ethylene oxide can be converted to polyethylene oxide in the reaction below:

What type of reaction is this?

(A)   Addition polymerisation
(B)   Condensation polymerisation
(C)   Hydrolysis
(D)   Oxidation/Reduction

7   When 1-butene reacts rapidly with bromine water which of the following products is formed?

(A)   2,3- dibromobutene
(B)   1,2- dibromobutene
(C)   1,2- dibromobutane
(D)   2,3- dibromobutane

8   Which of the following statements best describes cellulose?

(A)   It is an addition polymer of glucose.
(B)   It is a condensation polymer of glucose.
(C)   It is a polyester.
(D)   It is a minor component of the biomass.

9   Some salts, when dissolved in water, produce acidic or alkaline solutions, while others produce neutral solutions. Which of the following is the CORRECT statement?

(A)   When sodium chloride is added to water, the pH increases.
(B)   When sodium ethanoate is added to water, the concentration of hydrogen ions increases.
(C)   When sodium carbonate is added to water, the pH decreases.
(D)   When ammonium nitrate is added to water, the concentration of the hydroxide ions decreases.

10   A soft drink can be carbonated according to the equilibrium shown below.

$$CO_{2\,(g)} \rightleftharpoons CO_{2\,(aq)}$$
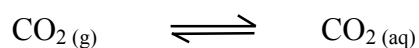
The soft drink may be decarbonated by heating. What conclusion can be drawn about this observation?

(A)   Only the forward reaction rate is increased by heating.
(B)   Only the reverse reaction rate is increased by heating.
(C)   Heating creates pressure, which drives the forward reaction.
(D)   The forward reaction is exothermic.

11   Which of the following pairs of solutions would be suitable as a buffer when mixed?

(A)   hydrochloric acid and potassium chloride
(B)   ethanoic acid and sodium ethanoate
(C)   sulfuric acid and sodium hydroxide
(D)   sodium hydroxide and water

12   In which of the following species does chromium have an oxidation state of +6?

(A) CrO_4^{2-}
(B) Cr_2O_3
(C) $CrCl_2$
(D) CrO_2

13   Which of the following will form a precipitate with aqueous iron(II) ions?

(A)   Silver nitrate solution
(B)   Barium chloride solution
(C)   Hydrochloric acid
(D)   Sodium hydroxide solution

14   Carbonyl chloride is prepared in the following exothermic reaction.

$$Cl_{2(g)} + CO_{(g)} \rightleftharpoons COCl_{2(g)}$$
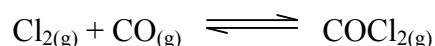
Which of the following conditions would favour the highest equilibrium yield of carbonyl chloride?

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

15   Four SGS boys tested a solution for the presence of a cation by adding selective anions as shown in the table below.

	Anions		
Boy	Chloride	Sulfate	Carbonate
I	Precipitate	Precipitate	Precipitate
II	Precipitate	No Precipitate	Precipitate
III	Precipitate	Precipitate	No Precipitate
IV	No Precipitate	Faint Precipitate	Precipitate

Each boy decided that the calcium ions were present in their solution.
Which set of results provides the best support for the presence of calcium ions?

(A)   Boy I
(B)   Boy II
(C)   Boy III
(D)   Boy IV

16   A student was testing a water sample for lead levels and he repeated his test ten times.
What feature of the student's experimental method is improved by repeating the test?

(A)   Accuracy
(B)   Validity
(C)   Control of variables
(D)   Reliability

17   Consider the following statements which refer to this system at equilibrium:

$$I_{2(s)} \rightleftharpoons I_{2(g)}$$
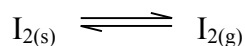
       (i)   No solid iodine remains.
       (ii)   The rates of vaporisation and condensation are equal.
       (iii)   The concentrations of solid iodine and gaseous iodine must be
               equal.
       (iv)   The reaction vessel must be sealed for equilibrium to be reached.

       Which of these statements are correct?

       (A)   (i) and (iv)
       (B)   (ii) and (iii)
       (C)   (ii) and (iv)
       (D)   (i) and (iii)

18   Promethium-155 is a radioactive isotope. Which of the following equations
       represents a possible nuclear reaction for the decay of promethium-155?

       (A) $^{155}_{61}Pm \rightarrow ^{155}_{62}Sm + \beta$ particle

       (B) $^{155}_{61}Pm \rightarrow ^{154}_{60}Nd + \beta$ particle

       (C) $^{155}_{61}Pm \rightarrow ^{151}_{65}Tb + \alpha$ particle

       (D) $^{155}_{61}Pm \rightarrow ^{151}_{57}La + \alpha$ particle

19   A chemist needs to differentiate between a slightly basic substance and a
       strongly basic substance using an indicator solution.
       What would be the best indicator for this task?

       (A)   Phenolphthalein
       (B)   Methyl orange
       (C)   Litmus
       (D)   Bromothymol blue

20   What is the order in which the molar heat of combustion for the following
       compounds will increase?

       (A)   Propanol, propane, butanol, butane
       (B)   Propane, propanol, butane, butanol
       (C)   Butanol, butane, propanol, propane
       (D)   Butane, butanol, propane, propanol

Masters' Initials	Candidate Number

Part B
Total marks (55)
Attempt ALL Questions
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

Question 21   (4 marks)   **Marks**

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

(a)   Calculate the theoretical mass of ethanol required to heat
250mL of water from 25.0°C to 40.0°C.

3

(b)   Identify an assumption you have made in this calculation.

1

Question 22   (3 marks)   **Marks**

The following graph shows the distribution of molecular weights of polymer molecules in a sample of polyethylene.
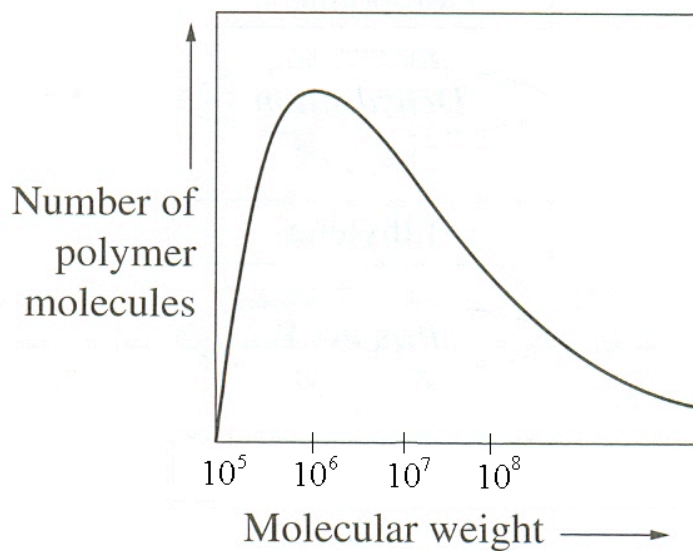
(a)   Explain why a range of molecular weights is observed.

_____   **1**

_____

(b)   Calculate the number of monomer units that are required to make the polymer molecule which is most frequently shown in the sample.

_____   **2**

_____

_____

_____

Masters' Initials	Candidate Number

Question 23   (5 marks)   **Marks**

You have performed a first-hand investigation to ferment glucose.

(a)   Write the chemical equation for this fermentation reaction.

_____   **1**

_____

(b)   Identify one important experimental condition needed for this
       reaction to proceed effectively.

_____   **1**

_____

(c)   Calculate:

   (i)   the mass of gaseous product formed from the fermentation
         of 10.0 g of glucose.

_____   **2**

_____

_____

_____

   (ii) the volume this gas would occupy at 25 ^{o}C and 100 kPa.

_____   **1**

_____

Question 24   (6 marks)   **Marks**

(a)   Identify a recently developed biopolymer that you have
        researched which is synthesised using an enzyme or organism.

                                                                        1

(b)   Describe the process used to produce the biopolymer, making reference to
        the required enzyme or organism.

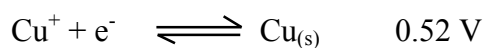   **3**

(c)   Describe a use or potential use of the polymer produced and relate this use
        to its properties.

                                                                        2

Masters' Initials	Candidate Number

Question 25   (2 marks)   **Marks**

$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$ 0.77 V

$Fe^{3+} + 3e^- \rightleftharpoons Fe_{(s)}$ -0.02 V

$Fe^{2+} + 2e^- \rightleftharpoons Fe$ -0.44 V

$Cu^{2+} + e^- \rightleftharpoons Cu^+$ 0.17 V

$Cu^{2+} + 2e^- \rightleftharpoons Cu_{(s)}$ 0.34 V

$Cu^+ + e^- \rightleftharpoons Cu_{(s)}$ 0.52 V
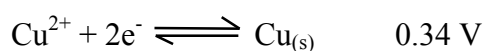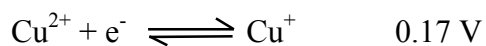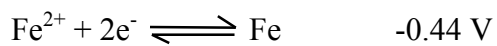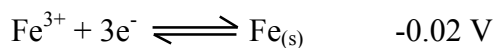
Using the Standard Electrode Potentials above, calculate the Electrode potentials for the following reactions and determine whether the reactions will proceed.

(a) $Cu_{(s)} + Fe^{2+}{}_{(aq)} \longrightarrow Cu^{2+}{}_{(aq)} + Fe_{(s)}$

_____   **1**

_____

(b) $Cu_{(s)} + 2Fe^{3+}{}_{(aq)} \longrightarrow Cu^{2+}{}_{(aq)} + 2Fe^{2+}{}_{(aq)}$
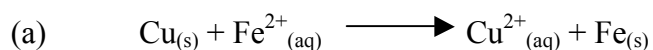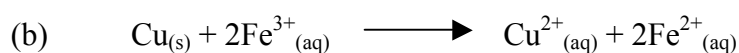
_____   **1**

_____

Question 26   (3 marks)   **Marks**

Describe the role of a chemist working in a named industry and a chemical principle used by this chemist.

3

_____

_____

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Question 27   (7 marks)

Michael performed a first-hand investigation to analyse the sulfate content of a fertiliser. He weighed out 0.586 g of a fertiliser sample. He then dissolved this sample in 25 mL of water using 10 drops of concentrated hydrochloric acid to assist with the solution. He analysed the sample using barium chloride solution and used an appropriate method to find the mass of sulfate in the fertiliser sample.

Michael's results were:

Mass of dry filter paper   1.005 g

Mass of dried filter paper and dry barium sulfate   2.111 g

   (a)   Write a net ionic equation for the precipitation of barium sulfate

1

_____

_____

Masters' Initials   Candidate Number

Question 27 continued   **Marks**

(b)   Calculate the number of moles of barium sulfate precipitated.

                                                                                          1

(c)   Calculate the mass of sulfate present in the fertiliser sample.

                                                                                          2

(d)   Calculate the percentage by mass of sulfate in the fertiliser sample.

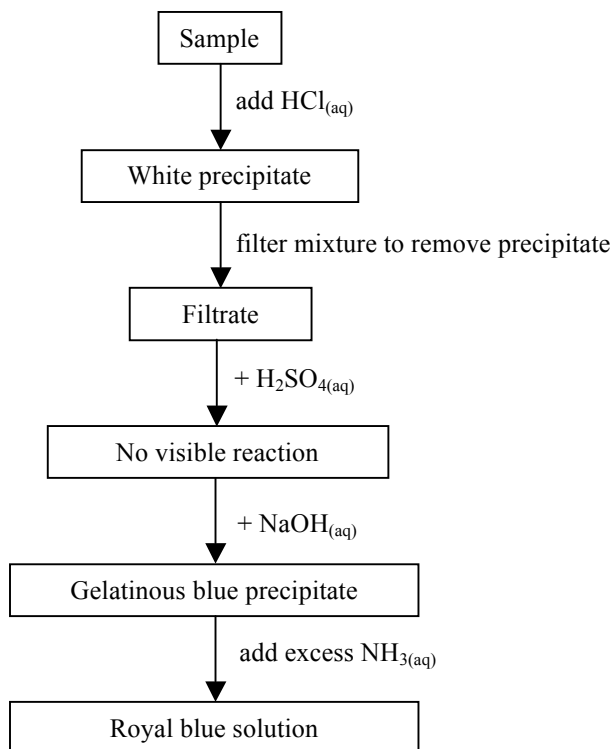   **1**

(e)   Identify a possible difficulty with this sulfate analysis and a way of dealing
        with the problem.

                                                                                          2

Question 28   (6 marks)   **Marks**

A chemist performed the tests shown on the flow chart below to identify two cations
present in a solution.

```
                        ┌──────────────┐
                        │    Sample    │
                        └──────────────┘
                                │  add HCl(aq)
                                ▼
                    ┌──────────────────────┐
                    │   White precipitate  │
                    └──────────────────────┘
                                │  filter mixture to remove precipitate
                                ▼
                        ┌──────────────┐
                        │   Filtrate   │
                        └──────────────┘
                                │  + H₂SO₄(aq)
                                ▼
                    ┌──────────────────────┐
                    │  No visible reaction │
                    └──────────────────────┘
                                │  + NaOH(aq)
                                ▼
                ┌──────────────────────────────┐
                │  Gelatinous blue precipitate  │
                └──────────────────────────────┘
                                │  add excess NH₃(aq)
                                ▼
                ┌──────────────────────────────┐
                │     Royal blue solution       │
                └──────────────────────────────┘
```

(a)   Identify the cations present in the solution.

                                                                                2

(b)   Justify your response to (a).

                                                                                4

Masters' Initials	Candidate Number

Question 29   (4 marks)   **Marks**

(a)   From the following list of chemicals, $H_2CO_{3(aq)}$, $HCO_3^-{}_{(aq)}$, $Al_2O_{3(s)}$, $NaNO_{3(aq)}$, complete the table below, using each of the chemicals listed once only.

Chemical	Acid/Base Properties
	an amphiprotic species
	no acid-base properties
	a weak acid

2

(b)   Explain, using equations, why the substance you identified as amphiprotic is classified in this way.

2

_____

_____

_____

_____

Question 30   (3 marks)

(a)   Write an equation, using structural formulae, for the esterification reaction between methanol and propanoic acid.

2

(b)   Identify the ester formed in (a) above.

1

_____

Question 31   (7 marks)   **Marks**

A primary standard solution was prepared:
    1.30g of sodium carbonate (Na_2CO_3) was dissolved in a volumetric flask and made up to 250mL.

A titration was performed
    The sodium carbonate solution was used to standardise a hydrochloric acid solution. On average 25.35 mL of hydrochloric acid was needed to neutralise 25.00mL portions of sodium carbonate.

(a)   **Calculate** the concentration in mol L^{-1} of the primary standard solution.

        1

(b)   **Calculate** the concentration of the hydrochloric acid solution.

        2

Question 31 continued on next page.

Masters' Initials   Candidate Number

Question 31 continued.   **Marks**

    (c)   **Calculate** the pH of the hydrochloric acid solution.

                1

    (d)   **Describe** the titration that was performed to standardise the hydrochloric acid. Identify which glassware is used for which solution and suggest a suitable indicator and the colour change that would be observed.

                3

Question 32 (1 mark)   **Marks**

Identify an everyday use of an indicator.

_____   **1**

_____

Question 33 (4 marks)

A pupil conducted a first-hand investigation to determine the effect on pH of adding salts to acids. The data collected is shown in the table below.

	acetic acid	hydrochloric acid
Initial concentration (mol L^{-1})	0.1	0.1
Initial pH	2.9	1
Salt added to 100mL of acid	1g solid sodium acetate	1g solid sodium chloride
Final pH	3.1	1

Analyse the results of this investigation.

_____   **4**

_____

_____

_____

_____

_____

_____

_____

Section II

25 marks
Attempt question 34 in this section.
Allow about 45 minutes for this section.

Answer the question in a **writing booklet**. Extra writing booklets are available.
Show **all** relevant working in questions involving calculations.

                                                                 Pages

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Question 34   (25 marks)   **Marks**

(a)   Identify a natural product that is not a fossil fuel whose world resources are   **3**
      shrinking, and discuss the use of replacement materials for this natural
      product.

(b)   The water-gas shift (WGS) reaction is an important industrial
      reaction used to produce hydrogen gas, often in conjunction with
      steam reforming. The chemical equation for the process is given
      below:

$$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$$
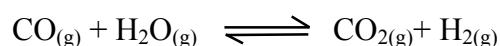
A 500 L reactor initially containing 1000 mol of carbon monoxide
and 1000 mol of water vapour is allowed to come to equilibrium in
the presence of a Raney Nickel catalyst at 230°C. The equilibrium
concentration of hydrogen gas is found to be 0.012 $molL^{-1}$.

(i)   Calculate the equilibrium constant for the WGS reaction at   **3**
          230°C.

The equilibrium constant for the WGS reaction at 430°C is 6.2 X 10^{-6}.

(ii)   Discuss factors likely to maximise yield and reaction rate for   **4**
          the WGS reaction whilst minimising cost.

Question 34 continued on next page.

Marks

(c)   In the Contact Process sulfur trioxide does not react with water directly, but instead it is first absorbed into concentrated sulfuric acid to form oleum. The oleum is then diluted with water in a separate vessel. Explain why the process is carried out in this way.   **2**

(d)   Describe a reaction of sulfuric acid as an oxidising agent (oxidant).   **2**

(e)   Outline the production of a soap in the school laboratory.   **2**

(f)   Account for the cleaning action of soaps.   **3**

(g)   Assess the use of the mercury cell and the diaphragm cell in the industrial production of sodium hydroxide.   **6**