SYDNEY GRAMMAR SCHOOL

# 2004
## FORM VI
## TRIAL HSC EXAMINATION

# Chemistry

## General Instructions

- 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 student number at the top of pages 7, 11, 15 and 19

**Total marks (100)**

**Section I** Pages 2 - 20

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 **(69)**
- Attempt Questions 16 - 29
- Allow about 2 hours for this Part

**Section II** Pages 21 - 28
Total marks **(16)**
- Attempt ONE Question from Questions 30 - 34
- Allow about 30 minutes for this Section

| CHECKLIST | |
|---|---|
| Each boy should have the following: | |
| 1 Question Paper | |
| 1 Multiple Choice Answer Sheet | |
| 1 4-page Writing Booklet | |

| | | | |
|---|---|---|---|
| 1 - MMB | 2 - AKBB | 3 - JAG | |
| 4 - AKBB | 5 - PRT | 6 - JAG | 7 - EPC |

# Part A

**Total marks (15)**
**Attempt ALL Questions**
**Allow about 30 minutes for this Part**

Use the multiple-choice Answer Sheet.

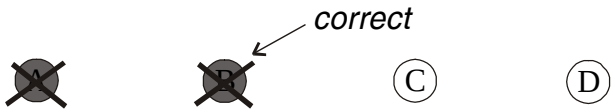
Select the alternative A, B, C or D that best answers the question. Fill the response circle completely.

**Sample** 2 + 4 =

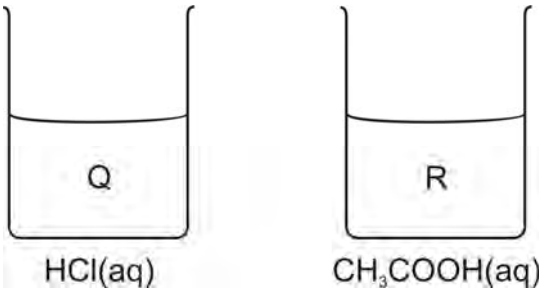
(A) 2 (B) 6 (C) 8 (D) 9


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


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.



**1**




Solution Q is a solution of hydrochloric acid (pH = 2.5), while solution R is a solution of acetic (ethanoic) acid (pH = 2.5).
Based on the above information and your knowledge of acids, which of the following statements is correct?

(A) Solution R is stronger than solution Q.
(B) Solution R is more concentrated than solution Q.
(C) Solution Q is more concentrated than solution R.
(D) Solution Q contains more $H^+(aq)$ than solution R.

**2** Which of the following statements about ozone is valid?

(A) Ozone depletion occurs only in the atmosphere above the South Pole.
(B) Ozone is a vital gas in the stratosphere.
(C) Ozone is a linear molecule.
(D) Ozone is destroyed only by chlorofluorocarbons.

**3** Which of the following types of radiation is the most penetrating?

(A) $\alpha$
(B) $\beta$
(C) $\gamma$
(D) ${}^{1}_{0}n$

**4** At what point is equilibrium reached in a reversible reaction?

(A) When reactants stop changing into products.
(B) When the molar concentrations of reactants and products are constant.
(C) When the molar concentrations of reactants and products are equal.
(D) When the activation energy of the forward and backward reactions are the same.

**5** A boy wished to classify lemon juice according to its acid/base characteristics. To do this he diluted some lemon juice and then added three drops of bromothymol blue. What colour would you expect this indicator to be in dilute lemon juice?

(A) Red
(B) Yellow
(C) Blue
(D) Colourless

**6** Which of the following is the most common anode in commercial primary galvanic cells?

(A) Zinc
(B) Mercury(II) oxide
(C) Manganese dioxide
(D) Lead

**7** Which of the following pairs of aqueous solutions will produce a precipitate on mixing?

(A) Sodium chloride and potassium nitrate
(B) Lead(II) chloride and potassium nitrate
(C) Potassium carbonate and barium nitrate
(D) Copper(II) sulphate and sodium chloride

**8** What is the common name for 2-hydroxypropane-1,2,3-tricarboxylic acid?

(A) Acetic acid
(B) Hydrochloric acid
(C) Sulphuric acid
(D) Citric acid

**9** Consider the following data:

| **Half-reaction** | **$E°_{red}$ / V** |
|---|---|
| $W^+ + e^- \rightarrow W$ | 2.3 |
| $X^{3+} + e^- \rightarrow X^{2+}$ | 0.7 |
| $Y^{2+} + 2e^- \rightarrow Y$ | -0.7 |
| $Z^{2+} + 2e^- \rightarrow Z$ | -1.7 |

Using the data above, which of the following is the best reducing agent?

(A) W
(B) $W^+$
(C) $Z^{2+}$
(D) Z

**10** Which of the following needs to be monitored by industrial chemists working in coal-fired power stations?

(A) Electricity generated by the station.
(B) Rate of formation of ammonia from its elements.
(C) Emission of steam and carbon dioxide.
(D) Emission of carbon monoxide and sulphur dioxide.

**11** Which of the following will affect the amount of hydrogen iodide gas present at equilibrium in this reaction?

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(A) Adding a catalyst.
(B) Adding an inert gas.
(C) Increasing the pressure.
(D) Increasing the temperature.

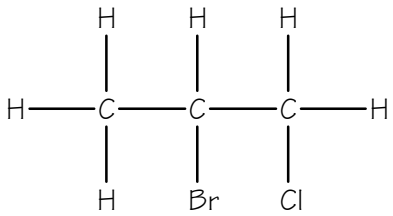
**12** Which of the following is the most commercially significant addition polymer?

(A) Nylon
(B) PVC
(C) PET
(D) Starch

**13** Which of the following statements about neutralization is correct?

(A) Neutralization is an electron transfer and is endothermic.
(B) Neutralization is an electron transfer and is exothermic.
(C) Neutralization is a proton transfer and is endothermic.
(D) Neutralization is a proton transfer and is exothermic.

**14** What is the IUPAC name of the following compound?




(A) 2-bromo-3-chloropropane
(B) 1-chloro-2-bromopropane
(C) 2-bromo-1-chloropropane
(D) 2-chloro-2-bromopropane

**15** In the nuclear transformation below, what is X?

$$^{10}_{5}\mathrm{B} + \alpha \rightarrow {}^{13}_{7}\mathrm{N} + \mathrm{X}$$

(A) An electron
(B) A proton
(C) A neutron
(D) A positron

Class

Student Number

## Part B

**Total marks (69)**
**Attempt ALL Questions**
**Allow about 2 hours for this Part**

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

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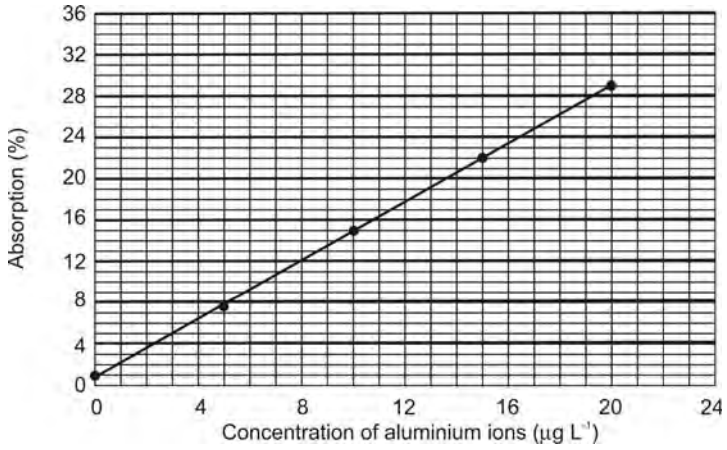
**Marks**

**Question 16** (2 marks)

Atomic absorption spectroscopy (AAS) can be used as an analytical tool for finding the concentration of elements in the ppm range. The graph below shows the relationship of absorption against concentration of aluminium ions. **2**




Use this graph to determine the $Al^{3+}$ concentration in ppm for a sample which registered an absorption of 10%.

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**Marks**

**Question 17** (6 marks)

The equation $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ represents the synthesis of ammonia from its component gases and is known as the Haber process.

(a) Describe the geo-political conditions under which Haber developed the industrial synthesis of ammonia and evaluate its significance at this time in world history. **3**

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(b) Explain why the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium. **3**

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**Marks**

**Question 18** (5 marks)

Atomic absorption spectroscopy (AAS) is an extremely useful tool in the detection of metal ion concentrations.

(a) Explain why AAS is of little use in identifying unknown substances. **3**

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(b) Explain how AAS has had a major impact on the scientific understanding of the effects of trace elements. **2**

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**Marks**

**Question 19** (6 marks)

The fermentation of glucose is a chemical process which has been known to humans for at least 5 thousand years.

(a) Write a chemical equation to represent the fermentation of glucose. **2**

(b) Under what physical conditions is fermentation optimised? **1**

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(c) One of the products of the fermentation process is frequently used as a solvent for both polar and non-polar solutes. Account for ethanol's ability to do this. **3**

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**Section I – Part B (continued)**

Class

Student Number

**Marks**

**Question 20** (5 marks)

Fossil fuels, which at present make up the bulk of the raw material used in the plastics industry, are a finite resource and likely to become severely depleted in the near future. Biopolymers have been suggested as a possible replacement for the petrochemicals produced from fossil fuels.

(a) Cellulose is often considered the most useful compound from which to produce biopolymers. Describe the structure of cellulose. **2**

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(b) (i) Identify a biopolymer which has recently been developed or is in the process of being developed, for commercial use. **1**

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(ii) Name the specific enzyme or organism used to synthesise this biopolymer. **1**

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(c) Suggest one benefit (apart from their renewability), of using biomass to produce polymers. **1**

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**Marks**

**Question 21** (3 marks)

(a) Draw electron dot diagrams to show:

(i) an oxygen molecule. **1**

(ii) an ozone molecule. **1**

(b) State the difference in stability of ozone gas and oxygen gas. **1**

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**Marks**

**Question 22** (3 marks)

Esters are produced by reaction of an alkanoic acid and an alcohol.

(a) Name a straight-chained alkanoic acid. **1**

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(b) Name a primary alcohol. **1**

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(c) Name the ester that would be produced by refluxing this acid with this alcohol. **1**

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**Marks**

**Question 23** (7 marks)

Over time, the definitions of acids and bases have been refined. Using the historical development of ideas about acids, evaluate how advances in scientific understanding changed the direction of scientific thinking. **7**

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**Section I – Part B (continued)**

Class

Student Number

**Marks**

**Question 24** (5 marks)

A student was investigating the acid/base nature of salts, by adding the dry solid salts one at a time to water and then testing their pH.

When he did this with ammonium chloride, he noted that the pH < 7, and assumed that the following action had occurred.

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+$$

(a) Why does the above equation illustrate a Brönsted-Lowry acid, rather than an Arrhenius acid? **2**

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(b) From the above equation, give one example of an acid and its conjugate base, respectively. **1**

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(c) Briefly outline how you would perform a first-hand investigation to determine the concentration of an acidic substance using a computer-based technology. **2**

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**Marks**

**Question 25** (3 marks)

(a) Identify two metallic ions which are found in hard water. **1**

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(b) Describe a simple method of determining the hardness of water in a school laboratory. **2**

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**Marks**

**Question 26** (6 marks)

While we usually think of the air around us as neutral, the atmosphere naturally contains acidic oxides of carbon, nitrogen and sulfur.

(a) (i) Describe, using an equation, an example of a chemical reaction which releases sulfur dioxide. **2**

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(ii) Identify a natural source of sulfur dioxide. **1**

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(b) (i) Describe, using an equation, an example of a chemical reaction which releases an oxide of nitrogen. **2**

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(ii) Identify a natural source of nitric oxide (NO), a gas that is capable of destroying ozone, and is involved in the production of photochemical smog. **1**

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**Section I – Part B (continued)**

Class

Student Number

**Marks**

**Question 27** (4 marks)

(a) Discuss the conditions under which nuclei are stable. **2**

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(b) The two equations below represent the formation of significant artificial isotopes: **2**

$^{98}_{42}\text{Mo} + ^{1}_{0}\text{n} \rightarrow ^{99}_{42}\text{Mo} \rightarrow ^{99}_{43}\text{Tc} + ^{0}_{-1}\beta$

$^{14}_{7}\text{N} + ^{1}_{1}\text{H} \rightarrow ^{11}_{6}\text{C} + ^{4}_{2}\text{He}$

Tc-99 is the most widely used radioactive isotope for diagnostic studies in nuclear medicine. C-11 is incorporated into organic compounds and used as a tracer in positron emission tomography (PET).

Discuss the production of commercial isotopes using these and / or other relevant examples.

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**Marks**

**Question 28** (6 marks)

Galvanic cells were constructed using the metals A – E and the voltages measured under standard conditions. The results are shown in the table below.

| **Cell reaction** | **$E°_{cell}$ / V** |
|---|---|
| $A + B^{2+} \rightarrow A^{2+} + B$ | 0.98 |
| $B + D^{2+} \rightarrow B^{2+} + D$ | 1.05 |
| $2C + B^{2+} \rightarrow 2C^{+} + B$ | 1.68 |
| $B + B^{2+} \rightarrow B^{2+} + B$ | 0.00 |
| $B + E^{2+} \rightarrow B^{2+} + E$ | 0.66 |

(a) Draw a labelled diagram of one of the cells used and identify clearly the reference cell. **3**

(b) Explain what is meant by standard conditions. **1**

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**Question 28 continued on page 21**

**Marks**

Question 28 (continued)

(c) Construct a table of standard (half-cell) potentials from the data collected. **1**

(d) (i) Identify the best reducing agent. **1**

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(ii) Identify the best oxidising agent.

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**Marks**

**Question 29** (8 marks)

Polyethylene is a chemical which has been of significant commercial importance in the past fifty years.

(a) Outline the major steps in the industrial production of polyethylene, from the raw material used, to the finished product. **3**

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(b) Many commercial polymers are produced by the modification of ethene molecules, such that a hydrogen is replaced by a side group, followed by a polymerisation reaction.

(i) Identify one such "modified ethene" monomer, either by its common or systematic name, and using complete structural formula, write an equation to represent the polymerisation reaction, using **three** monomer units. **3**

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**Question 29 continued on page 23**

**Marks**

Question 29 (continued)

(ii) Describe a use for the polymer you have identified, in part (i), in terms of its physical or chemical properties. **2**

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## Section II

**Total marks (16)**
**Attempt ONE question from Questions 30 - 33**
**Allow about 30 minutes for this Section**

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

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**Marks**

**Question 30 - Industrial Chemistry** (16 marks)

(a) Industrial chemists have researched and developed replacements for some natural products.

(i) Identify one dwindling natural resource that is not a fossil fuel. **1**

(ii) Name a material that has been manufactured to replace the natural product identified in part (i). **1**

(iii) Explain why this replacement material is now manufactured. **1**

(b) (i) Describe the use of sulphuric acid as a dehydrating agent. **1**

(ii) Explain how sulphuric acid may be used as an oxidant. **2**

(c) Phosgene, or carbonyl chloride, $COCl_2$, is a colourless, poisonous gas used in the production of some polymers. Carbonyl chloride decomposes as shown in the following equation. **3**

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

1.00 mol of carbonyl chloride was placed in a 10.0 L sealed flask at 1250°C. At equilibrium 0.20 mol of carbonyl chloride was present in the flask. Calculate the value of the equilibrium constant for the decomposition of carbonyl chloride at 1250°C.

(d) Chemistry laboratories buy 18M (concentrated) sulphuric acid and dilute this so that they are able to make the concentrations needed for day-to-day analysis. **3**

Explain how you would **safely** dilute 18M sulphuric acid to make 2M sulphuric acid. Include safety precautions.

(e) Sulfuric acid is such an important chemical in industry that its annual production may be used as an index of a nation's industrial activity. **4**

Explain why sulphuric acid is such an important industrial chemical using three different industrial uses of sulphuric acid.

**End of Question 30**

**Marks**

**Question 33 - Chemistry of Art** (16 marks)

(a) Modern cosmetics are carefully formulated to be beneficial to the skin, or at least not harmful, but this was not always the case. Some of the pigments used in ancient Egyptian, Greek and Roman make-up are given below.

| | | |
|---|---|---|
| Face make-up | White lead | $2PbCO_3.Pb(OH)_2$ |
| Lipstick | Cinnabar | HgS |
| Eye-shadow | Orpiment | $As_2S_3$ |
| Mascara | stibnite | $Sb_2S_3$ |

(i) What is the modern systematic name for orpiment? **1**

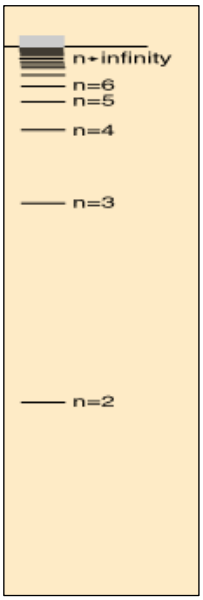
(ii) What are some of the safety hazards associated with these pigments? **2**

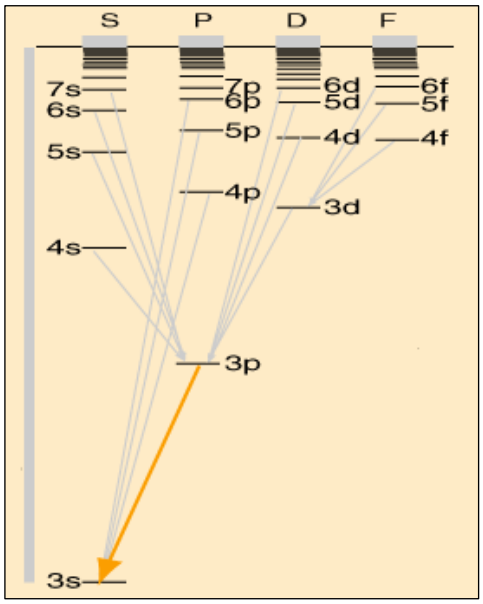
(b) (i) Identify the components of a paint. **1**

(ii) Outline the processes and chemistry involved to prepare and attach pigments to surfaces in a named example of a medieval or earlier artwork. **2**

(c) Explain the relationship between UV/visible absorption and reflectance spectra. **3**

(d) Explain the main features of atomic absorption and emission spectra, making reference to the energy level diagrams for sodium and hydrogen (see below). **3**



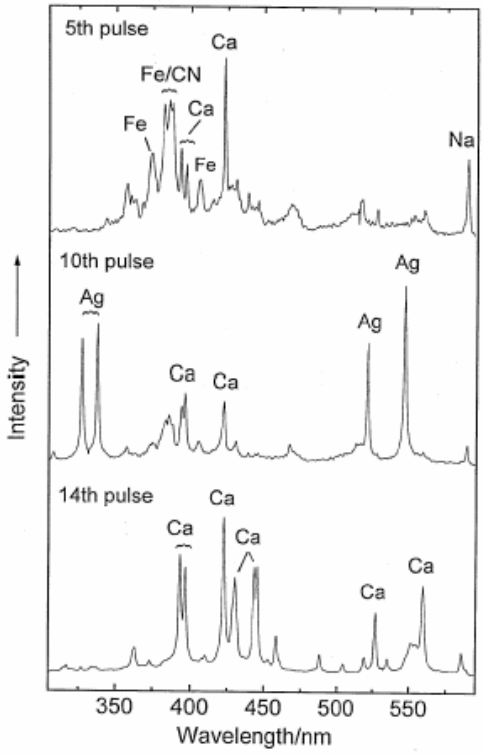

**Question 33 continues on page 29**

**Marks**

Question 33 (continued)

(e) In laser microspectral analysis (LMA) a high energy laser pulse vaporises a minute amount of the material. Consecutive pulses dig deeper and deeper into the artwork, so that depth profiling is possible. The technique is very sensitive, using samples as small as $10^{-7}$ g. It may also be coupled with other techniques that can identify the individual pigments. **4**

**Russian icon of St Nicholas**




The results of one LMA experiment on a nineteenth century Russian icon are shown above. A brown pigment in the paint is separated from the white ground by a metallic layer; the backing is wood.

Analyse the results and suggest compositions for the components of the three layers. Justify your answer.

**End of Question 33**

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# Chemistry

## Data Sheet

| | | |
|---|---|---|
| Avogadro's constant, $N_A$ ……. | | $6.022 \times 10^{23}$ mol$^{-1}$ |
| Volume of 1 mole ideal gas: | at 100 kPa and | |
| | at 0 °C (273 K) …… | 22.71L |
| | at 25 °C (298K) …… | 24.79 L |
| Ionisation constant for water at 25°C (298.15 K), $K_w$ ……. | | $1.0 \times 10^{-14}$ |
| Specific heat capacity of water …….. | | $4.18 \times 10^3$ Jkg$^{-1}$K$^{-1}$ |

## Some useful formulae

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

## 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 |
| $SO_4^{2-} + 4H^+ + 2e^-$ | $\rightleftharpoons$ | $SO_{2(g)} + 2H_2O$ | 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 |
| $\frac{1}{2} O_2 + 2H^+ + 2e^-$ | $\rightleftharpoons$ | $H_2O$ | 1.23 V |
| $\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$ | $\rightleftharpoons$ | $Cr^{3+} + \frac{7}{2} H_2O$ | 1.36 V |
| $\frac{1}{2} Cl_{2(g)} + e^-$ | $\rightleftharpoons$ | $Cl^-$ | 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 |

# PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — Symbol of element — Name of element

Atomic Weight

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 $^{99}Tc$.

SYDNEY GRAMMAR SCHOOL

CRIB
Class

Student Number

# 2004
## HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

# Chemistry
## Section I Part A
## ANSWER SHEET

### General Instructions

- Write your class and candidate number in the space provided.
- Attempt all questions 1 – 15
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response circle completely.

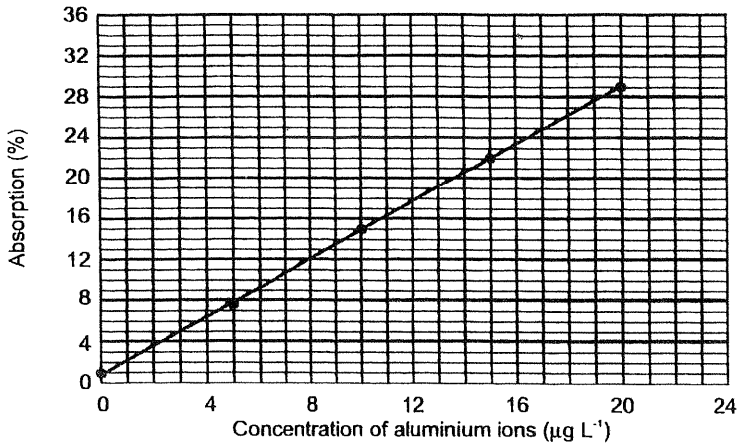
| | | | | | % correct |
|---|---|---|---|---|---|
| 1. | A | **B** | C | D | 72 |
| 2. | A | **B** | C | D | 94 |
| 3. | A | B | **C** | D | 97 |
| 4. | A | **B** | C | D | 74 |
| 5. | A | **B** | C | D | 57 * |
| 6. | **A** | B | C | D | 79 |
| 7. | A | B | **C** | D | 54 * |
| 8. | A | B | C | **D** | 98 |
| 9. | | B | C | **D** | |
| 10. | A | B | C | **D** | 78 |
| 11. | A | B | C | **D** | 67 |
| 12. | A | **B** | C | D | |
| 13. | A | B | C | **D** | 69 |
| 14. | A | B | **C** | D | 69 |
| 15. | A | B | **C** | D | 74 |

PART B

**Marks**

**Question 16** (2 marks)

Atomic absorption spectroscopy (AAS) can be used as an analytical tool for finding the concentration of elements in the ppm range. The graph below shows the relationship of absorption against concentration of aluminium ions. 2




Use this graph to determine the $Al^{3+}$ concentration in ppm for a sample which registered an absorption of 10%.

Marks

16 $Al^{3+}$ conc$^{n}$ 6.5 μg L$^{-1}$ 1

or $6.5 \times 10^{-3}$ ppm 1

If this $Al^{3+}$ conc$^{n}$ were misread from the graph, but logical value in ppm ⟶ 1 mark.

N.B Boys often wrote $[Al^{3+}]$ for the concentration of $Al^{3+}$.

**Question 17** (6 marks)

The equation $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ represents the synthesis of ammonia from its component gases and is known as the Haber process.

(a) Describe the geo-political conditions under which Haber developed the industrial synthesis of ammonia and evaluate its significance at this time in world history. 3

17 (a) Just prior to WW I Germany realised it was losing its access to natural fertilisers eg saltpetre, guano. Then Allies' naval blockade prevented importation of saltpetre from S America & so Germany needed to develop production of ammonia → home production of fertilisers and explosives

As the Haber process → $NH_3$ → prolonged WW I as Germans had synthetic fertilisers for their food production + $NH_3$ used in making explosives.

| | Marks |
|---|---|
| Good description | 3 |
| Reasonable description | 2 |
| V. brief description | 1 |
| Wrong world war (eg WW II) | −1 |
| 'importing $NH_3$, rather than nitrogen compounds' | −1 |

17 (b) Explain why the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium. 3

17(b) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} + heat$

Forward reaction is exothermic

∴ T↑ → rate of reaction ↑, but will decrease yield of $NH_3$ (Le Chatelier's principle)

Catalyst → lower Ea → equilibrium reached faster, reasonable reaction rate.

(pressure) P↑ favours $NH_3$ yield (Le Chatelier's principle)

Removal of $NH_3$ also 'pulls' reaction to rhs (again Le Chatelier)

Marks

Logical discussion.

including T, catalyst, P or removal of $NH_3$ and idea of compromise → 3 marks

Reasonable discussion.

- T↑ and catalyst
or temp and removal of $NH_3$
+ some idea of compromise – 2 marks

Some points describing the Haber process 1 mark.

**Marks**

**Question 18** (5 marks)

Atomic absorption spectroscopy (AAS) is an extremely useful tool in the detection of metal ion concentrations.

(a) Explain why AAS is of little use in identifying unknown substances. 3

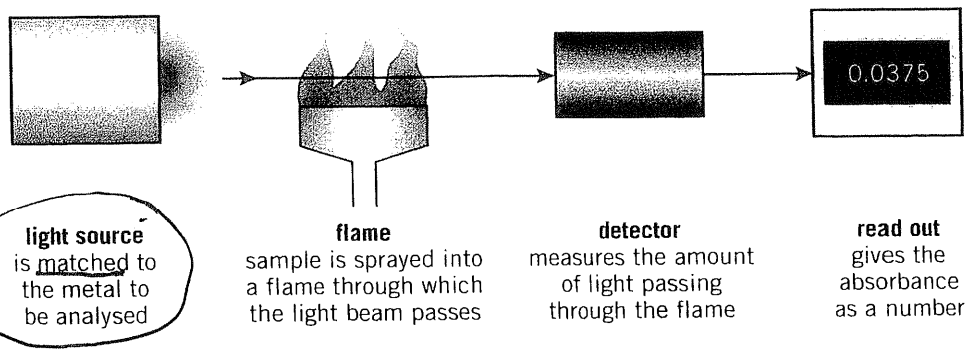



Figure 11.5
**A diagrammatic representation of an atomic absorption spectrometer.**

18 (a)

Atoms absorb & emit characteristic light frequencies
AAS [lamp/lightsource] emits light of specific frequency of (metallic) element under test.
If sample does not contain the same element as in the AAS light source, then it is very unlikely that light will be absorbed in the AAS detector and the 'read out' to be meaningful.
∴ AAS can't be used for an unknown substance.
little use in identifying non-metallic compounds.

| Marks | |
|---|---|
| Coherent explanation | 3 |
| Reasonable explanation | 2 |
| Some background on AAS | 1 |

18 (b) Explain how AAS has had a major impact on the scientific understanding of the effects of trace elements. 2

.....

18 (b).

AAS may be used to detect cations in very low concns – ppm to ppb.

∴ This technique can measure trace elements, eg Co, Mn beneficial to crops + animals in very low concns.

Marks – must mention detection at very low concn – ppm or ppb 1

Give an example of the use of AAS measuring a trace (of Hg accepted) metal by name. 1

**Question 19** (6 marks)

The fermentation of glucose is a chemical process which has been known to humans for at least 5 thousand years.

(a) Write a chemical equation to represent the fermentation of glucose. 2

$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$

Equation must include correct states for 2 marks

(Balanced eqtn, but incorrect states: 1 mark)

(b) Under what physical conditions is fermentation optimised? 1

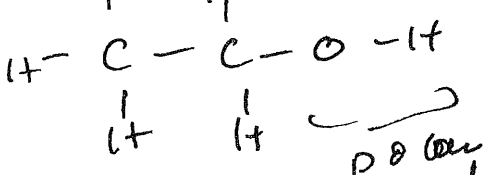
(b) Anaerobic or low $O_2$

Temp. – body temp or 37 °C / or even 'room temp' } both needed for 1 mark.

'Moderate temp' – not accepted.

9. (c) One of the products of the fermentation process is frequently used as a solvent for both polar and non-polar solutes. Account for ethanol's ability to do this. 3

(c) Ethanol



small non-polar gp. — enables ethanol to form dispersion forces with non-polar substances eg I2, hydrocarbons

polar end. — enables ethanol to form H-bond bonds and dipole-dipole forces with polar molecules. eg $H_2O$, glucose,

Good account - including polar + non-polar sections of ethanol molecule
- types of i/m forces possible with polar + non-polar ends of molecule.
- egs of polar + non-polar solutes

Marks
(3)

Reasonable account (2)

Some description of ethanol as a solvent - eg like dissolves like

CRIB
Class

Student Number

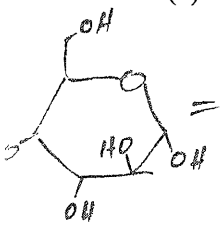
**Section I – Part B (continued)**

**Marks**

**Question 20** (5 marks)

Fossil fuels, which at present make up the bulk of the raw material used in the plastics industry, are a finite resource and likely to become severely depleted in the near future. Biopolymers have been suggested as a possible replacement for the petrochemicals produced from fossil fuels.

(a) Cellulose is often considered the most useful compound from which to produce biopolymers. Describe the structure of cellulose. **2**




= A

Cellulose is a polymer chain made from repeating glucose monomers, where every second monomer is inverted. ...A-V-A-V-A...

(b) (i) Identify a biopolymer which has recently been developed or is in the process of being developed, for commercial use. **1**

(eg) PHA (or another biopolymer)
(NB: ethanol is not a polymer!)

(ii) Name the specific enzyme or organism used to synthesise this biopolymer. **1**

(eg) Alcaligenes eutrophes

(c) Suggest one benefit (apart from their renewability), of using biomass to produce polymers. **1**

• Biopolymers generally are biodegradable
OR • Conservation of crude oil for use as fuel
OR • (+ others)

**Marks**

**Question 21** (3 marks)

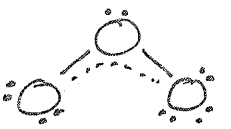
(a) Draw electron dot diagrams to show:

(i) an oxygen molecule. 1

Generally well done

(ii) an ozone molecule. (– Must be bent!) 1

Is really a resonance structure – not in syllabus
∴ had to accept "incorrect" octet version.



(* Do NOT use $O_3$ as an example of a co-ordinate covalent bond – use $NH_4^+$ or $H_3O^+$)

(b) State the difference in stability of ozone gas and oxygen gas.

| $O_3$ | $O_2$ |
|---|---|
| unstable | stable |
| (+ others) | |

**Marks**

**Question 22** (3 marks)

Esters are produced by reaction of an alkanoic acid and an alcohol.

(a) Name a straight-chained alkanoic acid. 1

Propanoic acid (or other)

(b) Name a primary alcohol. 1

Ethanol (had to say 1-propanol etc if used $C_3$ or higher)

(c) Name the ester that would be produced by refluxing this acid with this alcohol. 1

Ethyl propanoate (must be correct using (a) + (b))

**Marks**

**Question 23** (7 marks)

Over time, the definitions of acids and bases have been refined. Using the historical development of ideas about acids, evaluate how advances in scientific understanding changed the direction of scientific thinking. 7

~1776 Lavoisier
~1810 Davy
~1884 Arrhenius
~1923 Bronsted/Lowry

} NB contains oxygen ≠ contains $O_2$ !!!
all in syllabus (p55)

"Over time" + "historical development" mean that the order was important!

MARKING GUIDLINES (See syllabus p 55)

Part A

| | |
|---|---|
| • All 4 people (above) named – including their ideas – must be accurate & "in time" | (5) |
| • Omitted one person OR error of idea | (4) |
| • Omitted two people OR several errors OR omitted one person AND an error | (3) |
| • Omitted two people AND several errors | (2) |
| • One person & idea correct | (1) |

Part B EVALUATE – make a judgement based on .....
– determine the value of....

| | |
|---|---|
| Excellent evaluation | (2) |
| Good evaluation | (1) |

NB Did not accept a 'restatement of the question' as an evaluation.

**Section I – Part B (continued)** CRIB

AKBB
Class

Student Number

**Marks**

**Question 24** (5 marks)

A student was investigating the acid/base nature of salts, by adding the dry solid salts one at a time to water and then testing their pH.

When he did this with ammonium chloride, he noted that the pH < 7, and assumed that the following action had occurred.

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+$$

(a) Why does the above equation illustrate a Brönsted-Lowry acid, rather than an Arrhenius acid? 2

No Arrhenius acid - ionises in water (1)
No produce $H^+$ ions. The above system does not.
Y Brönsted-Lowry acid - is defined as a (1)
proton donor. Both $NH_4^+$ & $H_3O^+$ donate a proton.

(b) From the above equation, give one example of an acid and its conjugate base, respectively. 1

$NH_4^+$ & $NH_3$ OR $H_3O^+ + H_2O$

(c) Briefly outline how you would perform a first-hand investigation to determine the concentration of an acidic substance using a computer-based technology. 2

Accurate description of hardware
(ie pH meter) — (1)
Conversion of raw data in to $[H^+]$ &
then acid conc — (1)

**Marks**

**Question 25** (3 marks)

(a) Identify two metallic ions which are found in hard water. 1

$Mg^{2+}$ + $Ca^{2+}$

(b) Describe a simple method of determining the hardness of water in a school laboratory. 2

* Titrating (brief description) – 1 MARK
with EDTA – 1 MARK

OR

* Add soap & shake – 1 MARK
Description of method including comparison
to other / Standard – 1 MARK.

OR

* Any alternative that would work
+ description

**Marks**

**Question 26** (6 marks)

$2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2(g)}$

While we usually think of the air around us as neutral, the atmosphere naturally contains acidic oxides of carbon, nitrogen and sulfur.

(a) (i) Describe, using an equation, an example of a chemical reaction which releases sulfur dioxide. 2

OR $4FeS_{2(s)} + 11O_{2(g)} \rightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$

OR $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$ Perfect - 2 MARKS

OR $2H_2S_{(g)} + 3O_{2(g)} \rightarrow 2SO_{2(g)} + 2H_2O_{(g)}$ Any mistake (-1)

(ii) Identify a natural source of sulfur dioxide. 1

Volcanic eruptions OR Bush fires OR Decaying organic matter

(b) (i) Describe, using an equation, an example of a chemical reaction which releases an oxide of nitrogen. 2

$NH_4NO_{3(s)} \rightarrow N_2O_{(g)} + 2H_2O_{(g)}$

$O_{2(g)} + N_{2(g)} \rightarrow 2NO_{(g)}$ Perfect - 2 MARKS

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ Any mistake (-1)

(ii) Identify a natural source of nitric oxide (NO), a gas that is capable of destroying ozone, and is involved in the production of photochemical smog. 1

Lightning

**Marks**

**Question 27** (4 marks) ✱ many confused n/p with p/n

(a) Discuss the conditions under which nuclei are stable. (SEE p102) 2

neutron-to-proton ratio lies within narrow limits (1)

too massive (Z > 82)

OR n/p too low for first 20 then increases to ~ 1.3 (1)

OR n/p too low K-capt/$\beta^+$ emits n/p too high $\beta$-decay

(b) The two equations below represent the formation of significant artificial isotopes: 2

$^{98}_{42}Mo + ^{1}_{0}n \rightarrow ^{99}_{42}Mo \rightarrow ^{99}_{43}Tc + ^{0}_{-1}\beta$

$^{14}_{7}N + ^{1}_{1}H \rightarrow ^{11}_{6}C + ^{4}_{2}He$

Tc-99 is the most widely used radioactive isotope for diagnostic studies in nuclear medicine. C-11 is incorporated into organic compounds and used as a tracer in positron emission tomography (PET).

NB not "use"

Discuss the production of commercial isotopes using these and / or other relevant examples.

neutron-rich isotopes like Tc-99 made in a nuclear reactor (1)

neutron-poor isotopes like C-11 made in a cyclotron (1)

(it is possible to make Tc-99 in a cyclotron but NOT by the process shown above)

* SEE pp 108/9

**Marks**

**Question 28** (6 marks)

Galvanic cells were constructed using the metals A – E and the voltages measured under standard conditions. The results are shown in the table below.

| **Cell reaction** | **$E°_{cell}$ / V** |
|---|---|
| $A + B^{2+} \rightarrow A^{2+} + B$ | 0.98 |
| $B + D^{2+} \rightarrow B^{2+} + D$ | 1.05 |
| $2C + B^{2+} \rightarrow 2C^{+} + B$ | 1.68 |
| $B + B^{2+} \rightarrow B^{2+} + B$ | 0.00 |
| $B + E^{2+} \rightarrow B^{2+} + E$ | 0.66 |

(a) Draw a labelled diagram of one of the cells used and identify clearly the reference cell. **3**

ALMOST NOBODY DID THIS !!

DIAG : 2× ½ cell
1 × salt bridge (1)
NEARLY DRAWN & CORRECTLY DRAWN (SCI CONV)

LABEL : M / $M^{2+}$ ×2
Salt bridge (1)
$e^-$ flow (OR) cathode // anode

ID the REF CELL $B/B^{2+}$ ½ cell (1)

(b) Explain what is meant by standard conditions. **1**

1 atm (or 1 bar) ; 25°C (or 298K) ; all concs 1 M
(all 3 required) (1)

**Question 28 continued on page 21**

**Marks**

Question 28 (continued)

(c) Construct a table of standard (half-cell) potentials from the data collected. 1

| | $E^{\circ}_{red}$ / V |
|---|---|
| $C^{+} + e^{-} \rightleftharpoons C$ | −1.68 |
| $A^{2+} + 2e^{-} \rightleftharpoons A$ | −0.98 |
| $B^{2+} + 2e^{-} \rightleftharpoons B$ | 0.00 |
| $E^{2+} + 2e^{-} \rightleftharpoons E$ | +0.66 |
| $D^{2+} + 2e^{-} \rightleftharpoons D$ | +1.05 |

ALL (1)

(d) (i) Identify the best reducing agent. 1

C (the most active metal)

(ii) Identify the best oxidising agent.

$D^{2+}$ (ion of the least active metal)

BOTH (1)

⊛ METALS cannot be oxidising agents

**Marks**

**Question 29** (8 marks)

Polyethylene is a chemical which has been of significant commercial importance in the past fifty years.

(a) Outline the major steps in the industrial production of polyethylene, from the raw material used, to the finished product. 3

FRACTIONAL DISTILLATION OF PETROLEUM / CRUDE OIL (1)

(CATALYTIC) CRACKING OF HIGHER FRACTIONS → ETHENE (1)

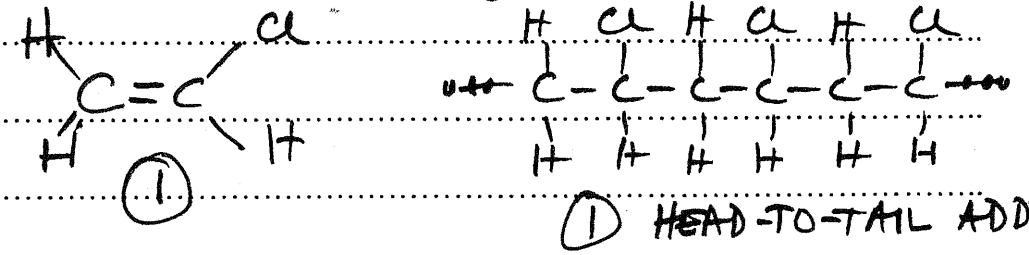
OR ( ADDITION POLYMERISATION OF ETHENE (1)
POLN. in pres of catalyst &/or high T, P )

ANSWERS often contained much INCORRECT (or poorly expressed) detail.

(b) Many commercial polymers are produced by the modification of ethene molecules, such that a hydrogen is replaced by a side group, followed by a polymerisation reaction.

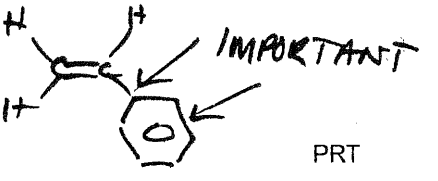
(i) Identify one such "modified ethene" monomer, either by its common or systematic name, and using complete structural formula, write an equation to represent the polymerisation reaction, using ~~three~~ monomer units. 3

Chloroethene or vinyl chloride (1) NOT POLYMER NAME



(1) HEAD-TO-TAIL ADDN.

MANY who chose styrene / phenylethene couldn't draw a benzene ring (phenyl group) or represent its connection to the vinyl group




**Question 29 continued on page 23**

**Marks**

Question 29 (continued) N.B.

(ii) Describe a use for the polymer you have identified, in part (i), in terms of its physical or chemical properties. **2**

(1) PROPERTY

(1) USE CONNECTED TO PROPERTY

(✱) REF/SOURCE pp 25/6

N.B. IF the property is the result of modification of the polymer by additives, formation of a foam etc, this had to be described explicitly in the answer. Thus, for example "PVC is flexible" is incorrect (sep 25)

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# The Chemistry of Art.

a(i) arsenic(III) sulfide (1)

(ii) Pigments can be inhaled as dust
ingested (from hands)
absorbed through cuts
} (1) any two

OR

Pb/Hg compounds are toxic } affect CNS
As/Sb compounds are toxic } body treats them like P } (1)
(1)

http://www.conmeg.com/sub/artpage/ART/ARTHmedieval.html

(b) (i) A paint consists of a pigment (1)
and a medium (binder)

(ii) The support is prepared by a layer of gesso
The paint is applied as egg tempera / pigment
mixed with egg yolk (1)

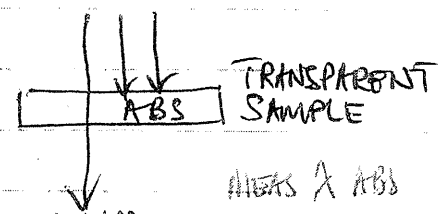
NB NOT TEMPURA

"St John the Baptist with St John the Evangelist & St James" (1)

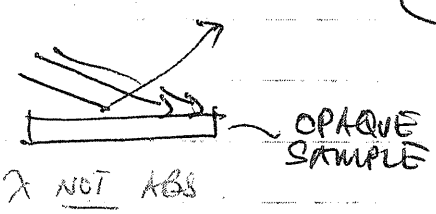
SIMPLE AND ENLIGHT

SPECTRUM (S)
SPECTRA (PL)
(C)

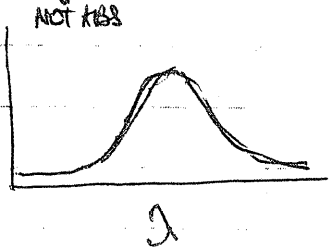
NOT: ATOMIC spectra

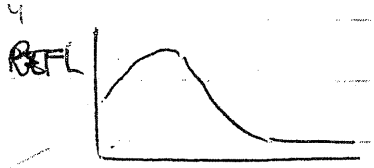



(1)




"Complementarity"




(1)

(1) A plot of absorption intensity (amt of light abs) against wavelength

A plot of intensity of refl. light against wavelength

OR

(1) Absorption associated with changes in $\bar{e}$ energy levels.

# CHEM OF ART

(2)

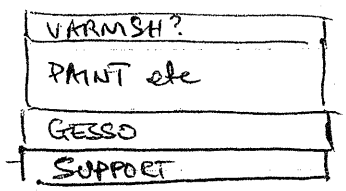
(d) (1) STATE FEATURES
- Sharp, discrete lines
- ABS black lines on coloured background
- EMN coloured lines on black background.
- Freq / λ of abs & em lines are the same.

(1) E emitted when ē move from higher E-level to a lower
E abs when ē move from lower E-level to a higher

(1) EXPLAIN FEATURES
Atoms with many electrons have more E-levels and more complex spectra than H.
Must refer to ~~spectra~~ diagrams given (say which is which ...)

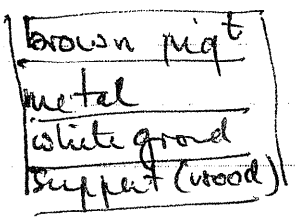
Q "EXPLAIN"

(e)




Pulses dig down (1)

ATOMS ID BY ATOMIC emission spectra




5th pulse brown pigment Fe present $Fe_2O_3$ (1)
(Ca & Na don't form coloured compounds) $FeO(OH)$

10th pulse metallic layer Ag present Ag (1)
(Ca is a very reactive metal)

14th pulse white ground Ca present $CaSO_4 \cdot xH_2O$ (1)
($CaCO_3$ (?) less likely)

30

CR1B-AKBB

ai eg Rubber — 1 MARK.

ii eg Styrene butadiene or neoprene — 1 MARK.

iii eg historical context WW II Japan/America.
or cost/efficiency
or no need for land clearance etc 1 MARK.
NB. Simply stating Tdemand was not sufficient.

bi Any specific example of $H_2SO_4$ as a dehydrating agent. (ie Sucrose or — 1 MARK.
Accepted this time ( $H_2SO_4$ acting as a catalyst in dehyd. reaction
but NOT GOOD examples ( OR dehydrating system in Eqn.

ii Conc $H_2SO_4$ plus example of oxidation — 1 MARK

Equation to represent this oxidation process — 1 MARK.
OR Simple redox oxidation < equation — 1 MARK
identification of oxidised species 1 MARK

c. $K = \dfrac{[CO][Cl_2]}{[COCl_2]}$ — 1 MARK.

$[Cl_2] = 0.08m, [CO] = 0.08m, [COCl_2] = 0.02M$ 1-MARK

$K = \dfrac{0.08^2}{0.02} = \underline{\underline{0.32}}$ 1 MARK

d.

$H_2SO_{4(l)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)} + Heat$

* extremely exothermic therefore may spit

Essential to add acid to water slowly (stirring) rather than vice versa so at worst only dilute acid will spit. 1-MARK

* $C_1V_1 = C_2V_2$ or actual calculation 1-MARK
  or $H_2SO_4$ 1 : 8 $H_2O$

* Must wear safety specs, gloves and protective clothing. 1-MARK.

OR If reasonable attempt at 2 or more of above points – 1 MARK

e. One tick does NOT equal one mark.!!

1 use mentioned – 0 MARKS
2 uses mentioned – 1 MARK
3 uses mentioned – 2 MARKS

PLUS

Details or equation of 1 use – 1 MARK
Details or equations of 2 uses – 2 MARKS.

NB- The production of ethene from ethanol is not currently a significant industrial process