SYDNEY GRAMMAR SCHOOL

2014
FORM VI
TRIAL HSC EXAMINATION

Chemistry

Thursday 31st July 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 Booklets

CHECKLIST	
Each boy should have the following :	
1 Question Paper	
1 Multiple Choice Answer Sheet	
2 Five Page Booklets	

Section I Pages 3 - 22

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 21-35
- Allow about 1 hour and 45 minutes for this Section

Section II Pages 23-26

Total marks **(25)**

- Attempt Question 36 in this section.
- Allow about 45 minutes for this Section

Chemistry Classes:

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

EXAMINERS: TW / CF / EJS / MTK / MRB

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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 =

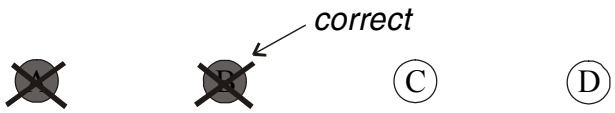
(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ Ⓑ Ⓒ Ⓓ

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 What is the conjugate base of H_2CO_3 according to the Brønsted-Lowry theory?

(A) CO_3^{2-}
(B) HCO_3^-
(C) $H_3CO_3^+$
(D) CO_2

2 Which of the following types of reaction are always exothermic?

I. Neutralisation
II. Decomposition
III. Combustion

(A) I only
(B) I and III only
(C) II and III only
(D) I, II and III

3 In two separate titrations, equal volumes and concentrations of hydrochloric acid and ethanoic acid are titrated with sodium hydroxide solutions of the same concentration. Which statement is correct?

(A) The initial pH values of both acids are equal.
(B) At the equivalence point, the solutions of both titrations have pH values of 7.
(C) The same volume of sodium hydroxide is needed to reach the equivalence point.
(D) The pH values of both acids increase at the same rate until the equivalence point is reached.

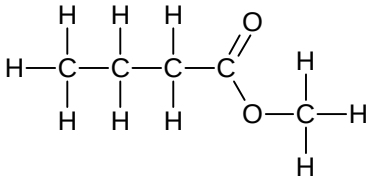
4 Consider an acid-base indicator solution.

$$\underset{\text{colour A}}{HIn_{(aq)}} \rightleftharpoons \underset{\text{colour B}}{In^-_{(aq)}} + H^+_{(aq)}$$

When a solution of sodium hydroxide is added to the indicator solution, which of the following changes takes place?

(A) Equilibrium position shifts to the right and more of colour B is seen.
(B) Equilibrium position shifts to the left and more of colour B is seen.
(C) Equilibrium position shifts to the right and more of colour A is seen.
(D) Equilibrium position shifts to the left and more of colour A is seen.

5 What is the IUPAC name for the following compound?



(A) butyl ethanoate
(B) butyl methanoate
(C) methyl propanoate
(D) methyl butanoate

6 A number of solutions were tested with a conductivity probe attached to a data logger. Which of the following solutions would record the highest conductivity reading?

(A) 0.01 mol L^{-1} HCl
(B) 0.1 mol L^{-1} HCl
(C) 0.01 mol L^{-1} CH_3COOH
(D) 0.1 mol L^{-1} CH_3COOH

7 Two identical flasks labelled A and B contain, respectively, 5.0 g of N_2 gas and 14.4 g of an unknown gas. The gases in both flasks are at standard laboratory conditions (SLC). What is the gas in flask B most likely to be?

(A) CO_2
(B) SO_2
(C) C_2H_6
(D) HBr

8 Four students were asked to test a solution for the presence of a cation by using various anions. The students obtained these results:

Student	*Chloride*	*Sulfate*	*Carbonate*
Alice	no precipitate	no precipitate	precipitate
Brian	precipitate	precipitate	no precipitate
Cathy	no precipitate	precipitate	precipitate
David	precipitate	no precipitate	no precipitate

Each student concluded that Cu^{2+} was present.

Which student had results consistent with this conclusion?

(A) Alice
(B) Brian
(C) Cathy
(D) David

9 A 1.424 g sample of lawn fertiliser was analysed for its sulfate content. After filtration and drying, 0.4810 g of barium sulfate was recovered.

What is the percentage by mass of sulfate in the lawn fertiliser?

(A) 13.90%
(B) 19.80%
(C) 33.77%
(D) 41.17%

10 AAS has advanced the quantitative analysis of metal ions in materials because:

(A) It unambiguously identifies the spectral fingerprint of a metal ion.
(B) Requires essentially no calibration, making it suitable for on-site analysis of authentic samples.
(C) Its sensitivity enables it to detect concentrations down to the parts per billion.
(D) It has discovered metals previously unknown to chemists.

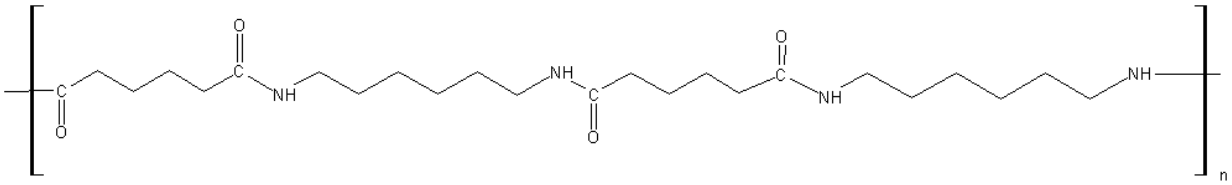
11 The flame test is useful to distinguish between calcium and barium containing compounds because:

(A) Only barium compounds burn in a flame.
(B) Flames containing barium salts are brick red whilst flames containing calcium salts are green.
(C) The flame for each ion is a different colour due to the different frequency of light emitted by the excited ions.
(D) All calcium and barium salts are soluble.

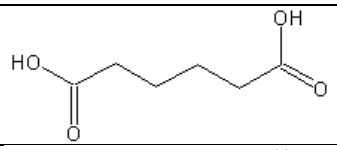
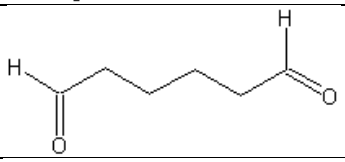
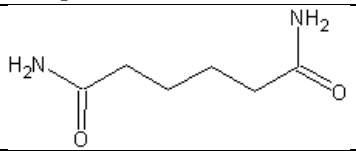
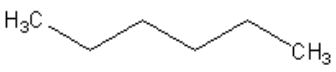
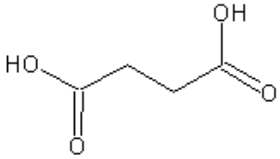
12 The catalyst used in the Haber process is:

(A) vanadium(V) oxide
(B) titanium and triethylaluminium
(C) iron-based
(D) zeolite

13 Nylon is a condensation polymer. Part of the structure of the polymer is shown.



What are the two monomers that form this polymer?

	Monomer 1	Monomer 2
(A)		
(B)		
(C)		
(D)		

14 Which of the following is true with respect to ethanol and petrol?

(A) Combustion of ethanol releases more energy per mole than combustion of petrol.
(B) Combustion of ethanol consumes less oxygen per gram than combustion of petrol.
(C) Combustion of ethanol produces more carbon dioxide per mole than combustion of petrol.
(D) Combustion of ethanol releases more energy per gram than combustion of petrol.

15 In a galvanic cell which of the following occurs?

(A) Electrolysis
(B) Oxidation at the cathode
(C) Negative ions migrating to the cathode
(D) A transfer of electrons from anode to cathode

16 In the following nuclear reaction, what is the identity of *X*?

$$^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + \mathrm{X}$$

(A) an electron
(B) an alpha particle
(C) a positron
(D) gamma radiation

17 Biopolymer chemistry is a new and rapidly expanding field. It is envisaged that in the future many materials will be made from, or contain, biopolymers. Which of the following statements is true?

(A) Biopolymers can only be produced by plants.
(B) The majority of manufactured biopolymers are produced by the modification of polyethylene.
(C) The petrochemical industry is the main source of biopolymers.
(D) A major advantage of biopolymers is that they are biodegradeable.

18 The process of catalytic cracking:

(A) can be catalysed by zeolites.
(B) transforms one long chain alkane into two shorter chain alkanes.
(C) cracks the solid catalyst into fragments to increase surface area.
(D) removes nitrogen oxides from car exhausts.

19 The heat of combustion for four alkanols, in kJ mol^{-1}, is:

Alkanol	**Molecular formula**	**Heat of combustion (kJ mol^{-1})**
methanol	CH_4O	726
ethanol	C_2H_6O	1367
1-pentanol	$C_5H_{12}O$	3331
2-methyl-1-butanol	$C_5H_{12}O$	3326

The alkanol above that produces the highest heat of combustion, in kJ g^{-1}, is:

(A) methanol
(B) ethanol
(C) 1-pentanol
(D) 2-methyl-1-butanol

20 In which of the following reactions does the metal atom show the greatest change in oxidation state?

(A) MnO_4^- to MnO_4^{2-}
(B) Cu^{2+} to Cu
(C) VO^{2+} to V^{3+}
(D) $Cr_2O_7^{2-}$ to Cr^{3+}

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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 (3 marks) **Marks**

The water in a farm dam, located near a coal-fired power station has a pH of 4.5. Account for this pH value.

3

Question 22 (4 marks)

60.00 mL of 0.1157 M acetic acid solution was added to 35.00 mL of 0.1035 M barium hydroxide solution. Assuming no volume change, calculate the final pH of the mixture.

4

Masters' Initials | Candidate Number

Question 23 (6 marks) **Marks**

The industrial production of hydrogen involves the following two reactions:

Reaction I $CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$ $\Delta H = +206$ kJ mol^{-1}
Reaction II $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$ $\Delta H = -41$ kJ mol^{-1}

(a) Write 'increase', 'decrease' or 'no change' in the table below to identify the expected effect of each change to reaction I and reaction II on the equilibrium yield of hydrogen.

Change to reaction I and reaction II	Effect of the change on the hydrogen yield in reaction I	Effect of the change on the hydrogen yield in reaction II
addition of steam at a constant volume and temperature		
addition of a suitable catalyst at a constant volume and temperature		
increase in temperature		

3

(b) Explain the effect of decreasing the volume, at constant temperature, on the hydrogen equilibrium yield in reaction I and reaction II.

3

Masters' Initials | Candidate Number

Question 24 (9 marks) **Marks**

The strength of the eggshell of birds is determined by the calcium carbonate, $CaCO_3$ content of the eggshell.
A student added 25.00 mL of 0.1638 M $HCl_{(aq)}$ to 0.1880 g of eggshell and the bubbling ceased. The excess acid left was then titrated with 23.80 mL of 0.1000 M aqueous sodium hydroxide.

(a) Calculate the chemical amount, in mol, of HCl added.

1

(b) Calculate the chemical amount, in mol, of acid that is in excess.

1

(c) State the equation for the reaction of HCl with the calcium carbonate in the eggshell.

1

(d) Calculate the percentage by mass of calcium carbonate in the eggshell sample.

4

Question 24 continued on next page.

Masters' Initials | Candidate Number

Question 24 continued. **Marks**

(e) Suggest a suitable indicator for this titration, justifying your choice.

1

(f) Other than the assumption that all the calcium carbonate reacted, deduce **one other** assumption made in arriving at the percentage of calcium carbonate in the eggshell sample.

1

Masters' Initials | Candidate Number

Question 25 (2 marks) **Marks**

Identify three industrial uses of ammonia.

2

Question 26 (3 marks)

For the particular chemical occupation you studied in detail, complete the following:

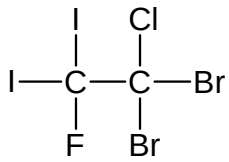
	Information gathered
Name of particular chemical occupation	
Industry in which this chemist is likely to be employed	
Example of work this chemist would undertake	

3

Masters' Initials | Candidate Number

Question 27 (1 mark) **Marks**

Name the following compound.



_____ **1**

Question 28 (2 marks)

Outline two differences between complete and incomplete combustion of fuels.

_____ **2**

_____

_____

_____

Masters' Initials | Candidate Number

Question 29 (4 marks) **Marks**

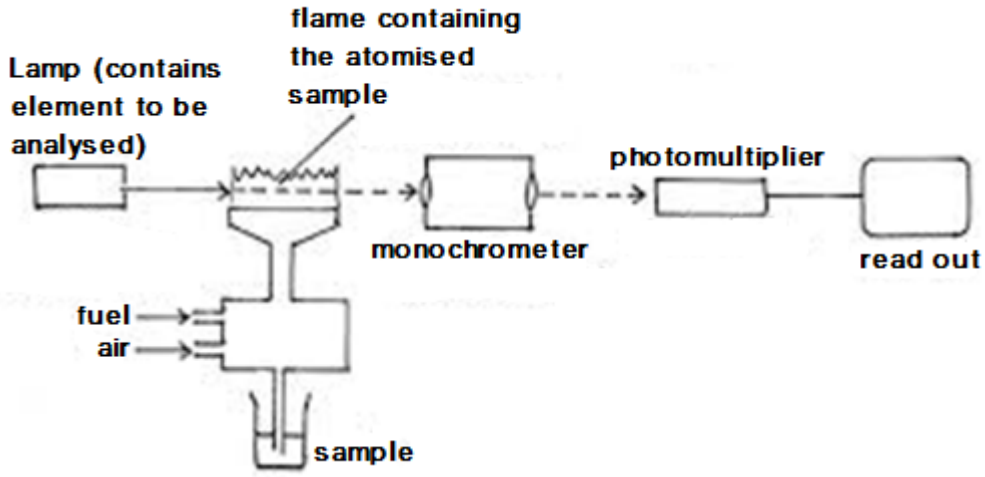
Describe the political conditions under which Haber developed the industrial synthesis of ammonia and evaluate its significance at that time in world history.

4

Masters' Initials | Candidate Number

Question 30 (2 marks) **Marks**

The schematic below is a simplified representation of an atomic absorption spectrometer.



(a) Explain why it is important to know the qualitative composition of a sample before it can be assayed by AAS.

1

(b) Outline one advantage of AAS over gravimetric analysis.

1

Masters' Initials | Candidate Number

Question 31 (5 marks) **Marks**

Compare and contrast the preparation of ethanol from plant material and crude oil.

5

Masters' Initials | Candidate Number

Question 32 (4 marks) **Marks**

Compare the production of condensation and addition polymers. Include a relevant chemical equation in your answer.

4

Masters' Initials | Candidate Number

Question 33 (5 marks) **Marks**

A pupil was given the five following metals to use as electrodes: zinc, magnesium, tin, lead and nickel. They were also given five aqueous solutions containing the corresponding divalent (2+) metal ions. The pupil was then asked to construct a galvanic cell with the largest potential difference.

(a) Which two metal electrode-solution pairs should they choose for their cell?

_____ **1**

_____

(b) Identify the oxidation and reduction half equations for the reaction occurring in part (a).

_____ **2**

_____

(c) Calculate the standard cell potential for the cell formed in part (a).

_____ **1**

_____

(d) Identify an appropriate substance for use in a salt bridge to complete the cell formed in part (a).

_____ **1**

_____

Masters' Initials | Candidate Number

Question 34 (3 marks) **Marks**

The following statement is from a radiology information for patients website. (http://www.radiologyinfo.org/en/info.cfm?pg=gennuclear#part_nine)

"Through the natural process of radioactive decay, the small amount of radiotracer in your body will lose its radioactivity over time. It may also pass out of your body through your urine or stool during the first few hours or days following the test. You should also drink plenty of water to help flush the radioactive material out of your body as instructed by the nuclear medicine personnel"

Explain how the duration of exposure and type of radioactive decay are important factors to consider when using radioactive materials for medicinal purposes.

3

Question 35 (2 marks)

Identify a method that can be used to detect ionising radiation and explain how it enables ionising radiation to be detected.

2

Masters' Initials | Candidate Number

Section II

25 marks
Attempt question 36 in this section.
Allow about 45 minutes for this section.

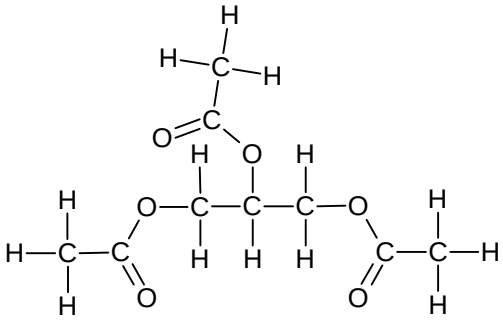
Answer the question in a **writing booklet**. Extra writing booklets are available.
Show **all** relevant working in questions involving calculations.

Masters' Initials | Candidate Number

Question 36 (25 marks) **Marks**

(a) Evaluate the progress currently being made to solve the issues associated with the increased need for a natural resource that is not a fossil fuel. **3**

(b) Triacetin (structure below) is a synthetic triglyceride that is commonly used as a food additive.



(i) Write a balanced chemical equation for the saponification of triacetin with potassium hydroxide. **2**

The **saponification number** of a fat or oil is defined as the mass (in milligrams) of potassium hydroxide required to saponify exactly one gram of the fat or oil.

(ii) Calculate the saponification number of triacetin. **3**

The saponification numbers of fats and oils typically used for soap-making are between 180 and 200.

(iii) Explain the difference between the saponification number of triacetin and the saponification numbers of fats and oils typically used for soap-making. **1**

Question 36 continued on next page.

Masters' Initials | Candidate Number

(c) Sulfur dioxide reacts with nitrogen dioxide in the equilibrium process shown below:

$SO_{2(g)} + NO_{2(g)} \rightleftharpoons SO_{3(g)} + NO_{(g)}$

When the reaction is allowed to come to equilibrium at 373 K, it is found that a 1 L vessel contains an equilibrium mixture 0.800 mol $SO_{2(g)}$, 0.100 mol $NO_{2(g)}$, 0.600 mol $SO_{3(g)}$ and 0.400 mol $NO_{(g)}$.

(i) Write the expression for the equilibrium constant. **1**

(ii) Calculate the value of K at 373 K. **1**

(iii) At 400 K, the value of K is 2.50. Is the forward reaction endothermic or exothermic? Justify your answer. **2**

(iv) If the temperature of the vessel is kept constant at 373 K and the volume is also kept constant, what chemical amount (in mol) of $NO_{(g)}$ needs to be added to the reaction vessel to give an equilibrium concentration of $NO_{2(g)}$ of 0.300 M? **2**

Question 36 continued on next page.

Masters' Initials | Candidate Number

Complete parts (d) and (e) in a new Answer Booklet.

(d) Sulfuric acid is an extremely useful and versatile industrial chemical. Describe, using balanced chemical equations, reactions of sulfuric acid acting as a dehydrating agent, oxidant and Brønsted-Lowry acid. **3**

(e) Before the Solvay process, most sodium carbonate was produced from sodium chloride, sulfuric acid, carbon and calcium carbonate via the Leblanc process, equations for which are shown below:

$2NaCl_{(s)} + H_2SO_{4(l)} \rightarrow Na_2SO_{4(s)} + 2HCl_{(g)}$
$Na_2SO_{4(s)} + 2C_{(s)} \rightarrow Na_2S_{(s)} + 2\ CO_{2(g)}$
$Na_2S_{(s)} + CaCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CaS_{(s)}$

Weathering of insoluble calcium sulfide waste to toxic, pungent hydrogen sulfide gas generated widespread public discontent.

The first modern air pollution legislation was enacted in 1863 by the British Parliament, who passed a law to curb emissions of hydrogen chloride gas from the Leblanc process. Over the subsequent 150 years, governments around the world have passed legislation to minimise the environment impacts of many industries.

Using the industrial production of **sodium hydroxide** and **sodium carbonate** as examples, critically evaluate the impact of these industries on the environment and how subsequent legislation has led to changes in the industrial processes used to produce these compounds. **7**

Data Sheet

Avogadro's constant, N_A ……		6.022×10^{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 ……		1.0×10^{-14}
Specific heat capacity of water ……..		4.18×10^3 Jkg^{-1}K^{-1}

Some useful formulae

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

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	79
Symbol	Au
Standard Atomic Weight	197.0
Name	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 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc 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 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 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 Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium						

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm 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 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Elements with atomic numbers 112 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of data. Some data may have been modified.

1 What is the conjugate base of H_2CO_3 according to the Brønsted-Lowry theory?

(A) CO_3^{2-}
(B) HCO_3^-
(C) $H_3CO_3^+$
(D) CO_2

2 Which of the following types of reaction are always exothermic?

I. Neutralisation
II. Decomposition
III. Combustion

(A) I only
(B) I and III only
(C) II and III only
(D) I, II and III

3 In two separate titrations, equal volumes and concentrations of hydrochloric acid and ethanoic acid are titrated with sodium hydroxide solutions of the same concentration. Which statement is correct?

(A) The initial pH values of both acids are equal.
(B) At the equivalence point, the solutions of both titrations have pH values of 7.
(C) The same volume of sodium hydroxide is needed to reach the equivalence point.
(D) The pH values of both acids increase at the same rate until the equivalence point is reached.

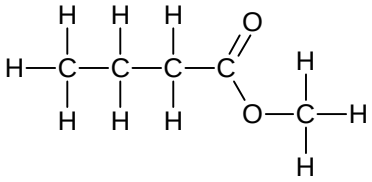
4 Consider an acid-base indicator solution.

$$\underset{\text{colour A}}{HIn_{(aq)}} \rightleftharpoons \underset{\text{colour B}}{In^-_{(aq)}} + H^+_{(aq)}$$

When a solution of sodium hydroxide is added to the indicator solution, which of the following changes takes place?

(A) Equilibrium position shifts to the right and more of colour B is seen.
(B) Equilibrium position shifts to the left and more of colour B is seen.
(C) Equilibrium position shifts to the right and more of colour A is seen.
(D) Equilibrium position shifts to the left and more of colour A is seen.

5 What is the IUPAC name for the following compound?



(A) butyl ethanoate
(B) butyl methanoate
(C) methyl propanoate
(D) methyl butanoate

6 A number of solutions were tested with a conductivity probe attached to a data logger. Which of the following solutions would record the highest conductivity reading?

(A) 0.01 mol L^{-1} HCl
(B) 0.1 mol L^{-1} HCl
(C) 0.01 mol L^{-1} CH_3COOH
(D) 0.1 mol L^{-1} CH_3COOH

7 Two identical flasks labelled A and B contain, respectively, 5.0 g of N_2 gas and 14.4 g of an unknown gas. The gases in both flasks are at standard laboratory conditions (SLC). What is the gas in flask B most likely to be?

(A) CO_2
(B) SO_2
(C) C_2H_6
(D) HBr

8 Four students were asked to test a solution for the presence of a cation by using various anions. The students obtained these results:

Student	*Chloride*	*Sulfate*	*Carbonate*
Alice	no precipitate	no precipitate	precipitate
Brian	precipitate	precipitate	no precipitate
Cathy	no precipitate	precipitate	precipitate
David	precipitate	no precipitate	no precipitate

Each student concluded that Cu^{2+} was present.

Which student had results consistent with this conclusion?

(A) Alice
(B) Brian
(C) Cathy
(D) David

9 A 1.424 g sample of lawn fertiliser was analysed for its sulfate content. After filtration and drying, 0.4810 g of barium sulfate was recovered.

What is the percentage by mass of sulfate in the lawn fertiliser?

(A) 13.90%
(B) 19.80%
(C) 33.77%
(D) 41.17%

10 AAS has advanced the quantitative analysis of metal ions in materials because:

(A) It unambiguously identifies the spectral fingerprint of a metal ion.
(B) Requires essentially no calibration, making it suitable for on-site analysis of authentic samples.
(C) Its sensitivity enables it to detect concentrations down to the parts per billion.
(D) It has discovered metals previously unknown to chemists.

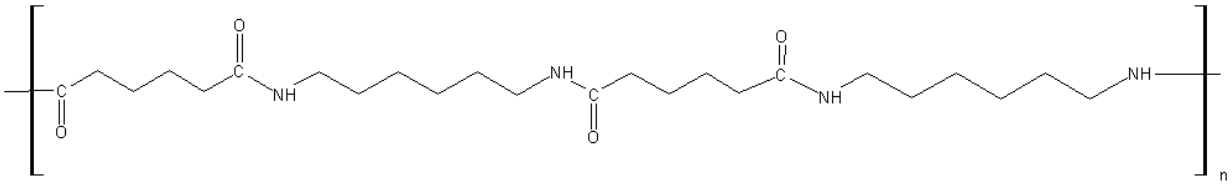
11 The flame test is useful to distinguish between calcium and barium containing compounds because:

(A) Only barium compounds burn in a flame.
(B) Flames containing barium salts are brick red whilst flames containing calcium salts are green.
(C) The flame for each ion is a different colour due to the different frequency of light emitted by the excited ions.
(D) All calcium and barium salts are soluble.

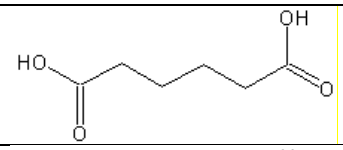
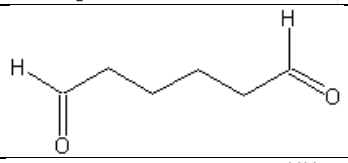
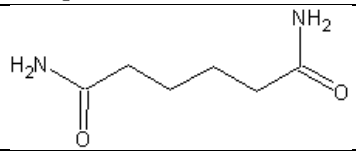
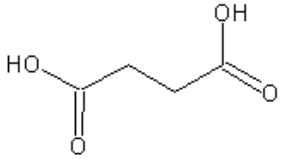
12 The catalyst used in the Haber process is:

(A) vanadium(V) oxide
(B) titanium and triethylaluminium
(C) iron-based
(D) zeolite

13 Nylon is a condensation polymer. Part of the structure of the polymer is shown.



What are the two monomers that form this polymer?

	Monomer 1	Monomer 2
(A)		
(B)		
(C)		
(D)		

14 Which of the following is true with respect to ethanol and petrol?

(A) Combustion of ethanol releases more energy per mole than combustion of petrol.
(B) Combustion of ethanol consumes less oxygen per gram than combustion of petrol.
(C) Combustion of ethanol produces more carbon dioxide per mole than combustion of petrol.
(D) Combustion of ethanol releases more energy per gram than combustion of petrol.

15 In a galvanic cell which of the following occurs?

(A) Electrolysis
(B) Oxidation at the cathode
(C) Negative ions migrating to the cathode
(D) A transfer of electrons from anode to cathode

16 In the following nuclear reaction, what is the identity of *X*?

$$^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + \mathrm{X}$$

(A) an electron
(B) an alpha particle
(C) a positron
(D) gamma radiation

17 Biopolymer chemistry is a new and rapidly expanding field. It is envisaged that in the future many materials will be made from, or contain, biopolymers. Which of the following statements is true?

(A) Biopolymers can only be produced by plants.
(B) The majority of manufactured biopolymers are produced by the modification of polyethylene.
(C) The petrochemical industry is the main source of biopolymers.
(D) A major advantage of biopolymers is that they are biodegradeable.

18 The process of catalytic cracking:

(A) can be catalysed by zeolites.
(B) transforms one long chain alkane into two shorter chain alkanes.
(C) cracks the solid catalyst into fragments to increase surface area.
(D) removes nitrogen oxides from car exhausts.

19 The heat of combustion for four alkanols, in kJ mol^{-1}, is:

Alkanol	Molecular formula	Heat of combustion (kJ mol^{-1})
methanol	CH_4O	726
ethanol	C_2H_6O	1367
1-pentanol	$C_5H_{12}O$	3331
2-methyl-1-butanol	$C_5H_{12}O$	3326

The alkanol above that produces the highest heat of combustion, in kJ g^{-1}, is:

(A) methanol
(B) ethanol
(C) 1-pentanol
(D) 2-methyl-1-butanol

20 In which of the following reactions does the metal atom show the greatest change in oxidation state?

(A) MnO_4^- to MnO_4^{2-}
(B) Cu^{2+} to Cu
(C) VO^{2+} to V^{3+}
(D) $Cr_2O_7^{2-}$ to Cr^{3+}

Question 21 (3 marks) **Marks**

The water in a farm dam, located near a coal-fired power station has a pH of 4.5. Account for this pH value.

Marks	Marking guidelines
3	• Identifies coal-fired power station as source of CO_2, SO_x or NO_x. • Relates emissions from power station to reactions with water to form acid rain, lowering pH. Can be shown by equation. • Recognises that a pH as low as 4.5 must arise from S/N impurities in coal and not just from carbonic acid formation in dam.
2	• Identifies coal-fired power station as source of CO_2, SO_x or NO_x. AND • Relates emissions from power station to acid rain, lowering pH.
1	• Identifies coal-fired power station as source of CO_2, SO_x or NO_x. OR • Identifies formation of acid rain, lowering pH.

Question 22 (4 marks)

60.00 mL of 0.1157 M acetic acid solution was added to 35.00 mL of 0.1035 M barium hydroxide solution. Assuming no volume change, calculate the final pH of the mixture.

1 mark - both

$n(CH_3COOH) = Vc = 60 \times 10^{-3} \times 0.1157 = 6.942 \times 10^{-3}$ moles

$n(Ba(OH)_2) = Vc = 35 \times 10^{-3} \times 0.1035 = 3.6225 \times 10^{-3}$ moles

2nd mark

$n(OH) = 2 \times n(Ba(OH)_2) = 7.245 \times 10^{-3}$ moles

$n(OH \text{ excess}) = 7.245 - 6.942 = 0.303 \times 10^{-3}$ moles

3rd mark

$c(OH) = n/V = 0.303 \times 10^{-3} / 95 \times 10^{-3} = 3.19 \times 10^{-2}$ M

4th mark - both

$p(OH) = 2.5$

$pH = 14 - 2.5 = 11.5$

Notes:

- *CE = carry error if working was given*
- *If 2 x OH step was missed, then CH_3COOH would be in excess. pH could not be calculated for weak acid without more information. 4th mark was awarded if this was recognised – but not as CE if pH was simply calculated.*

Question 23 (6 marks) **Marks**

The industrial production of hydrogen involves the following two reactions:

Reaction I $CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$ $\Delta H = +206 \text{ kJ mol}^{-1}$
Reaction II $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$ $\Delta H = -41 \text{ kJ mol}^{-1}$

(a) Write 'increase', 'decrease' or 'no change' in the table below to identify the expected effect of each change to reaction I and reaction II on the equilibrium yield of hydrogen.

Change to reaction I and reaction II	**Effect of the change on the hydrogen yield in reaction I**	**Effect of the change on the hydrogen yield in reaction II**
addition of steam at a constant volume and temperature	*increase*	*increase*
addition of a suitable catalyst at a constant volume and temperature	*No change*	*No change*
increase in temperature	*increase*	*decrease*

3 marks – all 6 correct
2 marks – 4-5 correct
1 mark – 1-3 correct

(b) Explain the effect of decreasing the volume, at constant temperature, on the hydrogen equilibrium yield in reaction I and reaction II.

1 mark
Identifies that as volume decreases, pressure increases AND that La Chatelier's Principle (LCP) says equilibrium system will shift to the side with less gas volumes to partially reverse this change.

2nd mark
Explains that reaction I has 2:4 gas volumes LHS:RHS, so system will shift to LHS, while reaction II is 2:2 so there will be no change.

3rd mark
Explicitly identifies the effect on the yield of H_2 (i.e. decrease in reaction I and no change in reaction II.).

Question 24 (9 marks) **Marks**

The strength of the eggshell of birds is determined by the calcium carbonate, $CaCO_3$ content of the eggshell.
A student added 25.00 mL of 0.1638 M $HCl_{(aq)}$ to 0.1880 g of eggshell and the bubbling ceased. The excess acid left was then titrated with 23.80 mL of 0.1000 M aqueous sodium hydroxide.

(a) Calculate the chemical amount, in mol, of HCl added.

$n = Vc = 25 \times 10^{-3} \times 0.1638 = 4.095 \times 10^{-3}$ moles **1**

(b) Calculate the chemical amount, in mol, of acid that is in excess.

n (HCl excess) $= n$ (NaOH) $= 2.38 \times 10^{-3}$ moles **1**

(c) State the equation for the reaction of HCl with the calcium carbonate in the eggshell.

$2\ HCl_{(g)} + CaCO_{3\,(s)} \rightarrow CaCl_{2\,(g)} + CO_2 + H_2O\ (l)$ **1**

States ignored – balancing and formulae only marked.

(d) Calculate the percentage by mass of calcium carbonate in the eggshell sample.

1 mark -
n(HCl reacted) = $4.095 - 2.38 = 1.715 \times 10^{-3}$ moles

2nd mark
n($CaCO_3$) = ½ x n(HCl) = 8.575×10^{-4} moles

3rd mark
m($CaCO_3$) = $8.575 \times 10^{-4} \times 100.09 = 8.583 \times 10^{-2}$ g

4th mark
% mass = $8.583 \times 10^{-2} / 0.188 \times 100 = 45.6\%$

Notes:

- *CE = carry error if working was given and could be followed.*

Question 24 continued. **Marks**

(e) Suggest a suitable indicator for this titration, justifying your choice.

Titration was HCl (strong acid) with NaOH (strong base), so neutral salt was formed; therefore Bromothymol blue as it changes around 7. **1**

(f) Other than the assumption that all the calcium carbonate reacted, deduce **one other** assumption made in arriving at the percentage of calcium carbonate in the eggshell sample.

Anything sensible e.g. no other impurities reacted with HCl, but marked easily. **1**

Masters' Initials | Candidate Number

Question 25 (2 marks) **Marks**

Identify three industrial uses of ammonia.

Any 3 distinct uses
- fertilizer.
- explosives
- cleaning agents

2

Question 26 (3 marks)

For the particular chemical occupation you studied in detail, complete the following:

	Information gathered
Name of particular chemical occupation	
Industry in which this chemist is likely to be employed	
Example of work this chemist would undertake	

3

3 marks for 3 linked informations
2 marks if information ~~is~~ one piece of information is unlinked or incorrect.
eg. 1 mark for identifying at least one item.

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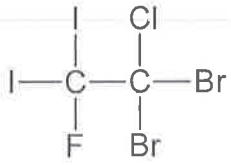
Question 27 (1 mark) **Marks**

Name the following compound.



spelling and number placement critical

1,1-dibromo-1-chloro-2-fluoro-2,2-diiodoethane. 1

Question 28 (2 marks)

Outline two differences between complete and incomplete combustion of fuels.

Any two. 2

Most popular.

(1) - $CO_2 + H_2O$ produced with complete combustion whilst C and CO combinations produced with incomplete combustion.

(2) - ΔH more negative for complete combustion reaction.

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Question 29 (4 marks) **Marks**

Describe the political conditions under which Haber developed the industrial synthesis of ammonia and evaluate its significance at that time in world history.

Marked holistically. Errors documented on each report paper. Information required

- Saltpetre - nitrate not ammonia source.
- Chilean Blockade / Germany.
- Haber process developed just prior to WWI.
- Used N_2, which was readily available.
- Fertilizer and explosives could be made with Germany - extending the war.

Significance

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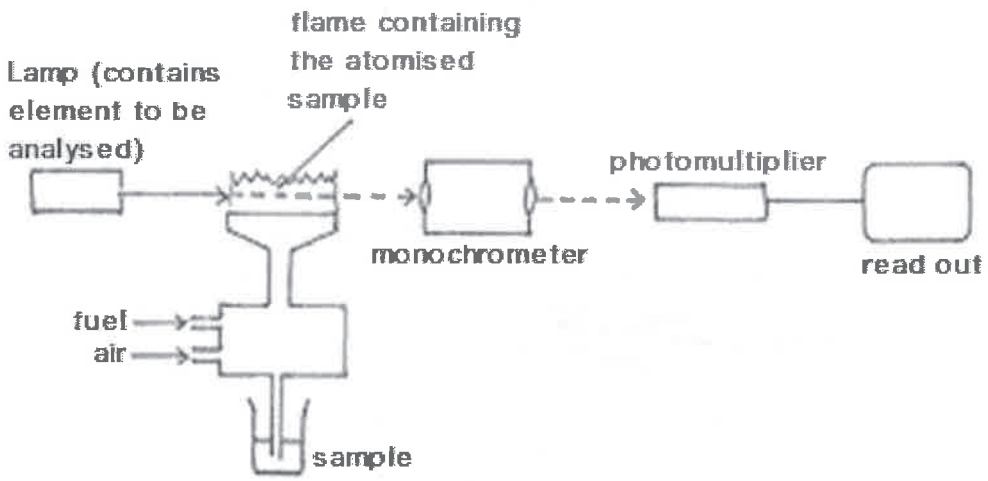
Question 30 (2 marks) **Marks**

The schematic below is a simplified representation of an atomic absorption spectrometer.



(a) Explain why it is important to know the qualitative composition of a sample before it can be assayed by AAS.

A frequency of light that is absorbed by the element must be produced by the lamp and isolated by the monochrometer. 1

(b) Outline one advantage of AAS over gravimetric analysis.

- It is much more sensitive 1

Ticks Do not indicate marks

Masters' Initials | Candidate Number

Question 31 (5 marks) **Marks**

Compare and contrast the preparation of ethanol from plant material and crude oil.

holistically marked 5

= Generally poorly done. - most give descriptors of processes but no comparison or contrast !!

① equation

½ for each comparison or contrast.

	Plant material	Oil
starting material	both large molecules.	
catalyst	enzymes	acid
Steps involved	both multistep.	
Energy inputs.	less	more
sources.	renewable	non renewable
efficiency Yield	less	more

Masters' Initials | Candidate Number

Question 32 (4 marks) **Marks**

Compare the production of condensation and addition polymers. Include a relevant chemical equation in your answer.

4

Over all poorly done. Boys seemed to list production of addition polymers but forgot to COMPARE to condensation. eg. if saying condensation polymerisation produces a by product the needed to say addition does not.
• Many also thought forming an ester is polymerisation
= A table is the best way to present info

{3 - marks for any correct production comparisons.
1 - mark an appropriate correct equation.

Addition	Condensation
. No by product produced	. small by product (molecule usually water produced.
double bonds break or rearrangement of electronic structure	reaction at functional groups.
Catalyst Though this can vary....	catalyst.
High temp pressure	room temp & pressure
genally 3 step process	- Can occur at other pH ranges.
Needs to be terminated	stops when reactants runs out.
etc	

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Question 33 (5 marks) **Marks**

A pupil was given the five following metals to use as electrodes: zinc, magnesium, tin, lead and nickel. They were also given five aqueous solutions containing the corresponding divalent (2+) metal ions. The pupil was then asked to construct a galvanic cell with the largest potential difference.

(a) Which two metal electrode-solution pairs should they choose for their cell? **1**

Magnesium
lead

(b) Identify the oxidation and reduction half equations for the reaction occurring in part (a). **2**

Oxidation: $Mg_{(s)} \longrightarrow Mg^{2+}_{(aq)} + 2e^-$
Reduction: $Pb^{2+}_{(aq)} + 2e^- \rightarrow Pb_{(s)}$

(1) mark correct equations
(1) mark correct labelling.

(c) Calculate the standard cell potential for the cell formed in part (a). **1**

$E^\ominus = 2.36\ V - 0.13V = 2.23\ V$

(d) Identify an appropriate substance for use in a salt bridge to complete the cell formed in part (a). **1**

Any thing that will not precipitate out with either ion solutions.

KNO_3 $NaCH_3COO$ etc.
$NaNO_3$

Masters' Initials | Candidate Number

Question 34 (3 marks) **Marks**

The following statement is from a radiology information for patients website. (http://www.radiologyinfo.org/en/info.cfm?pg=gennuclear#part_nine)

"Through the natural process of radioactive decay, the small amount of radiotracer in your body will lose its radioactivity over time. It may also pass out of your body through your urine or stool during the first few hours or days following the test. You should also drink plenty of water to help flush the radioactive material out of your body as instructed by the nuclear medicine personnel"

Explain how the duration of exposure and type of radioactive decay are important factors to consider when using radioactive materials for medicinal purposes.

(1) how long res 3

(1) shorter half life = less exposure

(1) either • β = travels further
or • β less ionising

(1) ~~why these conditions are needed~~ eg. reduces exposure ∴ less chance of damage ~~a~~ can be detected

Question 35 (2 marks)

Identify a method that can be used to detect ionising radiation and explain how it enables ionising radiation to be detected.

(1) naming Method 2

(1) for general how it works but more than just Clicks or changes colour. So what is ionised +

eg. Grieger counter

- Argon gas is ionised to form $Ar^+ + e^-$ which can pass a current to the electrodes.

Masters' Initials | Candidate Number

Section II

25 marks
Attempt question 36 in this section.
Allow about 45 minutes for this section.

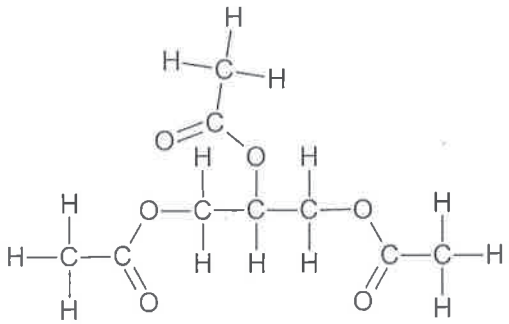
Answer the question in a **writing booklet**. Extra writing booklets are available.
Show **all** relevant working in questions involving calculations.

Masters' Initials | Candidate Number

Question 36 (25 marks) **Marks**

(a) Evaluate the progress currently being made to solve the issues associated with the increased need for a natural resource that is not a fossil fuel. **3**

(b) Triacetin (structure below) is a synthetic triglyceride that is commonly used as a food additive.



(i) Write a balanced chemical equation for the saponification of triacetin with potassium hydroxide. **2**

The **saponification number** of a fat or oil is defined as the mass (in milligrams) of potassium hydroxide required to saponify exactly one gram of the fat or oil.

(ii) Calculate the saponification number of triacetin. **3**

The saponification numbers of fats and oils typically used for soap-making are between 180 and 200.

(iii) Explain the difference between the saponification number of triacetin and the saponification numbers of fats and oils typically used for soap-making. **1**

Question 36 continued on next page.

Masters' Initials | Candidate Number

(c) Sulfur dioxide reacts with nitrogen dioxide in the equilibrium process shown below:

$$SO_{2(g)} + NO_{2(g)} \rightleftharpoons SO_{3(g)} + NO_{(g)}$$

When the reaction is allowed to come to equilibrium at 373 K, it is found that a 1 L vessel contains an equilibrium mixture 0.800 mol $SO_{2(g)}$, 0.100 mol $NO_{2(g)}$, 0.600 mol $SO_{3(g)}$ and 0.400 mol $NO_{(g)}$.

(i) Write the expression for the equilibrium constant. **1**

(ii) Calculate the value of K at 373 K. **1**

(iii) At 400 K, the value of K is 2.50. Is the forward reaction endothermic or exothermic? Justify your answer. **2**

(iv) If the temperature of the vessel is kept constant at 373 K and the volume is also kept constant, what chemical amount (in mol) of $NO_{(g)}$ needs to be added to the reaction vessel to give an equilibrium concentration of $NO_{2(g)}$ of 0.300 M? **2**

Question 36 continued on next page.

Masters' Initials | Candidate Number

Complete parts (d) and (e) in a new Answer Booklet.

(d) Sulfuric acid is an extremely useful and versatile industrial chemical. Describe, using balanced chemical equations, reactions of sulfuric acid acting as a dehydrating agent, oxidant and Brønsted-Lowry acid. **3**

(e) Before the Solvay process, most sodium carbonate was produced from sodium chloride, sulfuric acid, carbon and calcium carbonate via the Leblanc process, equations for which are shown below:

$2NaCl_{(s)} + H_2SO_{4(l)} \rightarrow Na_2SO_{4(s)} + 2HCl_{(g)}$
$Na_2SO_{4(s)} + 2C_{(s)} \rightarrow Na_2S_{(s)} + 2\ CO_{2(g)}$
$Na_2S_{(s)} + CaCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CaS_{(s)}$

Weathering of insoluble calcium sulfide waste to toxic, pungent hydrogen sulfide gas generated widespread public discontent.

The first modern air pollution legislation was enacted in 1863 by the British Parliament, who passed a law to curb emissions of hydrogen chloride gas from the Leblanc process. Over the subsequent 150 years, governments around the world have passed legislation to minimise the environment impacts of many industries.

Using the industrial production of **sodium hydroxide** and **sodium carbonate** as examples, critically evaluate the impact of these industries on the environment and how subsequent legislation has led to changes in the industrial processes used to produce these compounds. **7**

Q36(a)

① Identify an appropriate natural resource & associated issues (n.b. both the syllabus dot point and the question explicitly state "that is not a fossil fuel" yet many boys discussed replacements for crude oil).

① Describe details of progress being made to address the identified issues.

① Evaluates the progress being made (this was rather poorly done in many cases: be explicit!)

e.g. Evaluation: Excellent progress has been made...

(b)(i) $C_3H_5(O_2C_2H_3)_{3(l)} + 3KOH_{(aq)} \rightarrow C_3H_8O_{3(l)} + 3KCH_3COO_{(aq)}$

or equivalent with structural formulae.

(-1) per mistake

(ii) FW (triacetin) = [redacted] 218.202

$\therefore n(\text{triacetin in } 1g) = \frac{1\,g}{218.202\,g\,mol^{-1}} = 4.583 \times 10^{-3}\,mol$ ①

$\therefore n(KOH) = 3 \times 4.583 \times 10^{-3}\,mol = 13.75 \times 10^{-3}\,mol$ ①

$\therefore m(KOH) = 13.75 \times 56.108 = 771.4\,mg$ ①

$\therefore$ Saponification number is 771.4.

(iii) Triacetin has much shorter acid sidechains (C_2) than typical fats/oils used for soap-making (e.g. C_{16}), so it has a much smaller molar mass. Accordingly, 1g of triacetin contains a greater chemical amount of triglyceride, which will require a larger mass of KOH for complete saponification, hence its higher saponification number.

c(i) $K = \dfrac{[SO_3][NO_2]}{[SO_2][NO_2]}$

many boys neglected to mention this!!

(ii) $K = \dfrac{0.6 \times 0.4}{0.8 \times 0.1} = 3.0.$

(iii) As $K_{400K} < K_{373K}$, an increase in temperature favours the reverse reaction. According to Le Châtelier's principle, increasing the temperature favours the endothermic reaction, so the forward reaction must be <u>exothermic</u>.

(iv)

	$SO_{2(g)}$ +	$NO_{2(g)}$ ⇌	$SO_{3(g)}$ +	$NO_{(g)}$
I	0.800	0.100	0.600	0.400+x
C	+0.200	+0.200	−0.200	−0.200
E	1.000	0.300	0.400	0.200+x

either (1)

$$3 = \frac{0.4 \times (0.200+x)}{1.000 \times 0.300}$$

$\therefore 0.200+x = 2.25$

$\therefore x = 2.05 \Rightarrow n(NO \text{ added}) = 2.05$ mol. (1)

Q36 (d) EJS

Criteria	Marks
• Three correct equations (including states for sulfuric acid) and descriptions of each reaction.	3
• Three correct equations (including states for sulfuric acid) OR • Two correct equations (including states for sulfuric acid), both described	2
• At least one correct equation OR • At least one correct description	1

Q36 (e) EJS

Criteria	Marks
• Demonstrates thorough knowledge of NaOH productions methods, including relevant equations • Critically evaluates environmental impacts of each method • Evaluates the impact of legislation on changes in the production methods • Demonstrates through knowledge of Solvay process, including relevant equations • Critically evaluates environmental impacts of LeBlanc and Solvay processes • Evaluates the impact of legislation on the change from LeBlanc to Solvay • Demonstrates coherence and logical progression	7
• As above, with minor errors or omissions	6
• Describes NaOH production methods correctly • Describes environmental impacts of each method • Identifies the impact of legislation on changes in the production methods • Describes Solvay production methods correctly • Describes environmental impact of Solvay **or** Leblanc • Identifies the impact of legislation on changes in the production methods	5
• Outlines at least two NaOH production methods correctly • Outlines Solvay process correctly • Describes environmental impacts of each OR provides reasons for change in production processes	3-4
• Outlines processes OR • Describes environmental impacts OR • Provides reasons for change in production processes	1-2

Notes

- Plan a logical and coherent answer before you begin. If you just write everything you know about the topic, you are not going to address the question closely enough. For example, it might not be necessary to include every step of the Solvay process - think about which steps are relevant to the question.
- Many boys were vague about the environmental impact e.g. "mercury was used, which was bad for the environment".
- Just including a diagram of the process (e.g. a mercury cell) is not sufficient as a description. Especially if it's unlabeled and there are no equations!
- Don't use something in your evaluation that isn't discussed in your answer. If you didn't mention legislation anywhere in your answer, you can't conclude in your evaluation that legislation was highly significant.
- Know the relevant equations and terminology!!