BOARD OF STUDIES
NEW SOUTH WALES

2001

HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Write your Centre Number and Student Number at the top of pages 9, 13, 17 and 21

Total Marks – 100

Section I Pages 2–24

75 marks

This section has two parts, Part A and Part B

Part A – 15 marks

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

Part B – 60 marks

- Attempt Questions 16–27
- Allow about 1 hour and 45 minutes for this part

Section II Pages 25–31

25 marks

- Attempt ONE question from Questions 28–32
- Allow about 45 minutes for this section

Section I
75 marks

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

Use the multiple-choice answer sheet.

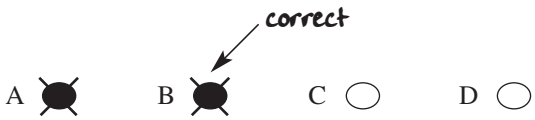
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

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



1 Ethene may be converted into poly(ethene).

What type of reaction is this?

(A) Condensation

(B) Hydrolysis

(C) Oxidation/reduction

(D) Polymerisation

2 Which of the following is a major component of biomass?

(A) Cellulose

(B) Ethanol

(C) Natural gas

(D) Oil

3 Which equation best represents catalytic cracking of a petroleum fraction?

(A) $C_{16}H_{34}(l) \xrightarrow{Al_2O_3} C_{16}H_{34}(g)$

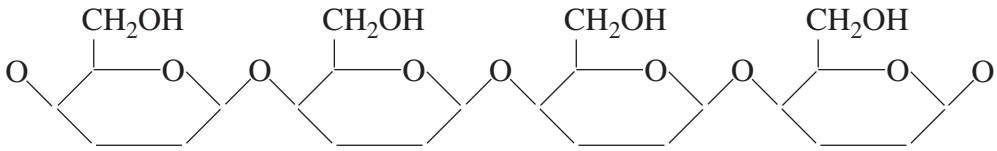
(B) $nC_2H_4(g) \longrightarrow -(-CH_2—CH_2-)_n\ (s)$

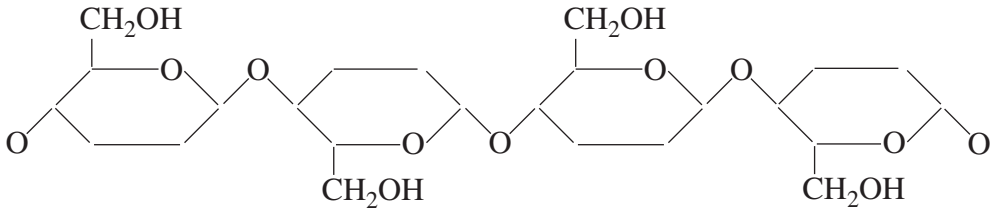
(C) $C_{16}H_{34}(l) \xrightarrow{Al_2O_3} C_7H_{16}(l) + 3C_2H_4(g) + C_3H_6(g)$

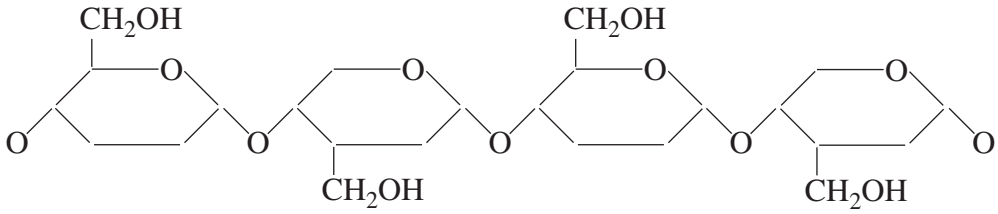
(D) $C_7H_{16}(l) + 3C_2H_4(g) + C_3H_6(g) \xrightarrow{Al_2O_3} C_{16}H_{34}(l)$

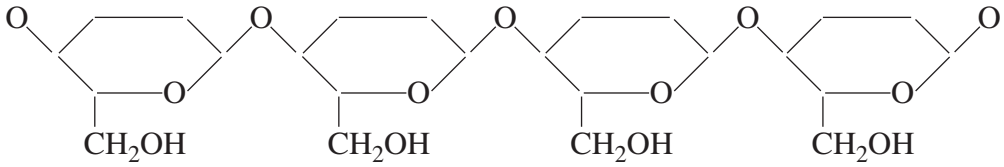
4 Cellulose is a linear polymer which is a basic structural component of plant cell walls.

Which is the correct representation of part of a cellulose polymer?

(A) 

(B) 

(C) 

(D) 

5 The pH of unpolluted rainwater is about 6.0. Which substance contributes most to this?

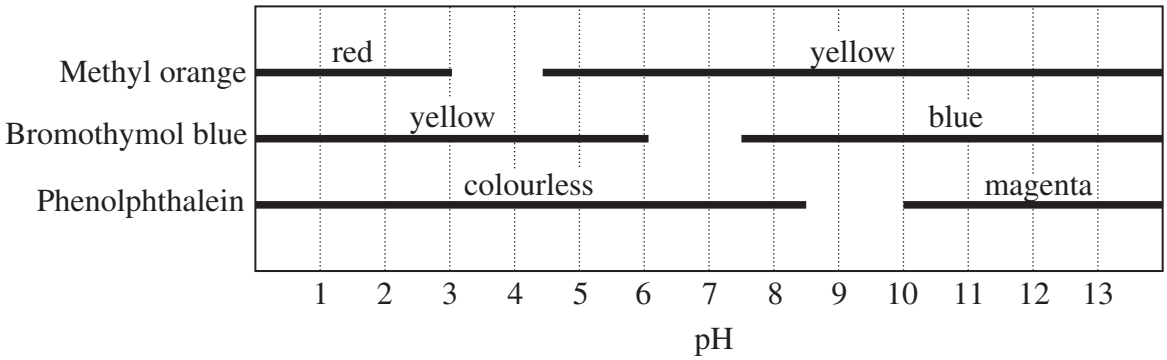
(A) CO_2

(B) N_2

(C) NO_2

(D) O_3

6 The graph shows the colour ranges of the acid–base indicators methyl orange, bromothymol blue and phenolphthalein.



A solution is yellow in methyl orange, blue in bromothymol blue and colourless in phenolphthalein.

What is the pH range of the solution?

(A) 4.5 to 6.0

(B) 6.0 to 7.5

(C) 7.5 to 8.5

(D) 8.5 to 10.0

7 A group of students produced a red solution by boiling red cabbage leaves in water. When dilute sodium hydroxide was added to the solution, it turned purple. When dilute hydrochloric acid was added to the red solution, no colour change occurred.

Which of these substances, when added, is most likely to cause the red solution to change colour?

(A) Cleaning solution containing ammonia

(B) Concentrated hydrochloric acid

(C) Orange juice

(D) Vinegar

8 The burning of sulfur can be described by the following equation:

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

What volume of sulfur dioxide gas will be released at 25°C and 101.3 kPa when 8.00 g of sulfur is burnt?

(A) 3.06 L

(B) 6.12 L

(C) 12.24 L

(D) 24.47 L

9 An understanding of Le Chatelier's principle is important in the chemical industry. Which prediction can be made using this principle?

(A) The identity of products of a chemical reaction

(B) The effect of changes in temperature on the rates of reactions

(C) The effect of catalysts on the position of equilibrium reactions

(D) The effect of changes in the concentration of chemical substances in equilibrium

10 The following equations describe some reactions in the formation of acid rain:

$$SO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HSO_3^-(aq)$$

$$2H^+(aq) + 2HSO_3^-(aq) + O_2(g) \longrightarrow 4H^+(aq) + 2SO_4^{2-}(aq)$$

What would occur if some solid sodium sulfate (Na_2SO_4) were added to a sample of acid rain?

(A) The amount of $SO_2(g)$ would increase and the acidity of the solution would decrease.

(B) The amount of $SO_2(g)$ would increase and the acidity of the solution would increase.

(C) The amount of $SO_2(g)$ would be unchanged and the acidity of the solution would be unchanged.

(D) The amount of $SO_2(g)$ would be unchanged and the acidity of the solution would decrease.

11 Why is chlorine used to treat local water supplies?

(A) To make water suitable for swimming

(B) To kill micro-organisms living in the water

(C) To promote sedimentation of finely suspended solids

(D) To precipitate heavy metal ions such as lead and mercury

12 The atomic absorption spectrophotometer was developed by Sir Alan Walsh and his team at CSIRO in the 1950s. Its development was one of the most significant in Australian chemical technology. What did it provide?

(A) A rapid method to monitor chemical pollutants in water supplies

(B) The first method for determining the concentrations of metal ions in water supplies

(C) A method for determining the concentrations of hydrocarbons at very low concentrations

(D) A method for determining the concentrations of metal ions at very low concentrations

13 Four students analysed a sample of fertiliser to determine its percentage of sulfate.

Each student:

- weighed an amount of fertiliser;
- dissolved this amount in 100 mL of water;
- added aqueous barium nitrate;
- filtered, dried and weighed the barium sulfate precipitate.

Their results and calculations are shown in the table.

Student	*Mass of fertiliser used* (g)	*Mass of* $BaSO_4$ *weighed* (g)	*Percentage of sulfate in fertiliser* (%)
A	11.6	19.5	69.2
B	10.4	16.9	66.9
C	10.268	22.612	90.6
D	11.1	18.2	67.5

The percentage of sulfate calculated by Student *C* was significantly higher than that of the other students. Which is the most likely reason for this?

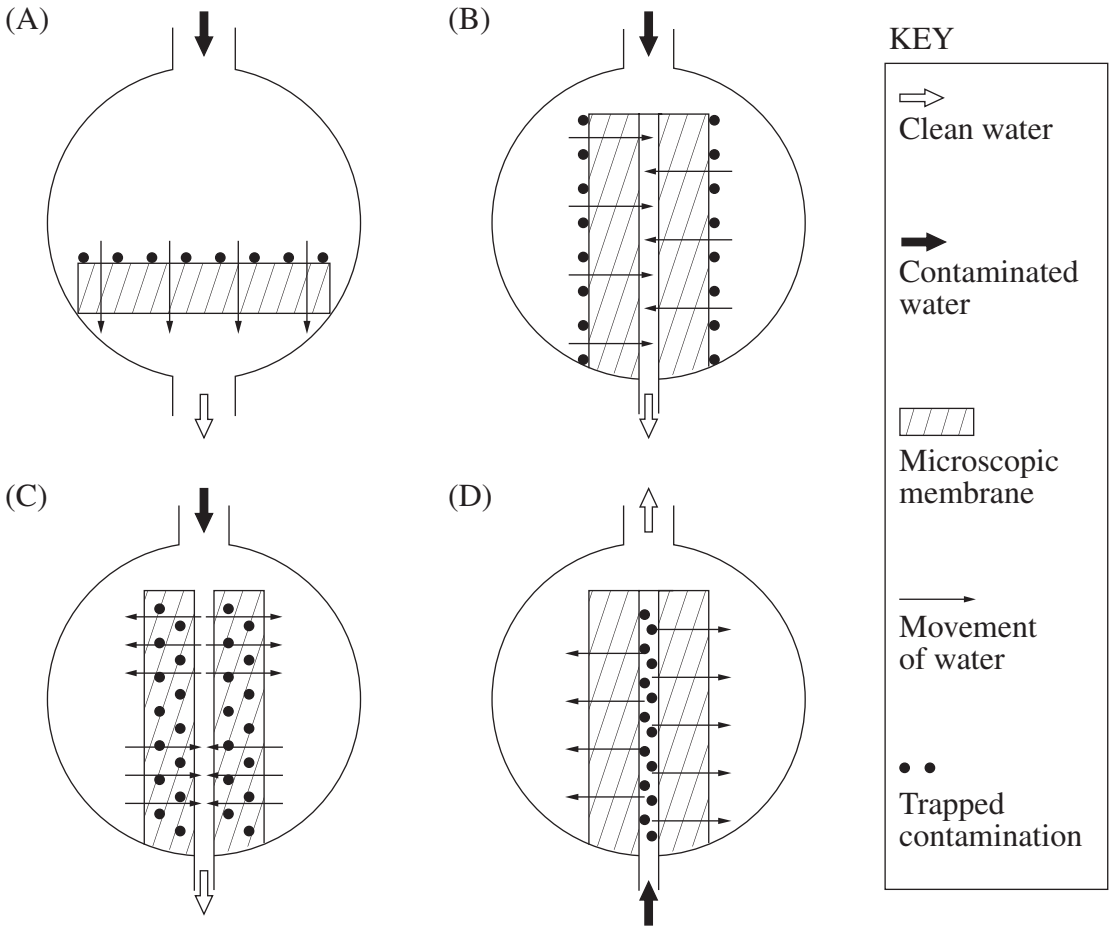
(A) Student *C* did not dry the sample for long enough.

(B) Student *C* added more $Ba(NO_3)_2$ solution than the other students.

(C) Student *C* used a balance capable of measuring weight to more decimal places.

(D) Student *C* waited longer than the other students for the $Ba(NO_3)_2$ to react completely with the sulfate.

14 Which diagram represents the most effective design for a microscopic membrane filter to purify contaminated water?



15 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*
A	no precipitate	no precipitate	precipitate
B	precipitate	precipitate	no precipitate
C	precipitate	precipitate	precipitate
D	no precipitate	precipitate	no precipitate

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

Which student had results consistent with this conclusion?

(A) *A*

(B) *B*

(C) *C*

(D) *D*

Centre Number

Student Number

Section I (continued)

Part B – 60 marks
Attempt Questions 16–27
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Marks

Question 16 (3 marks)

Radioisotopes are used in industry, medicine and chemical analysis. For ONE of these fields, relate the use of a named radioisotope to its properties. **3**

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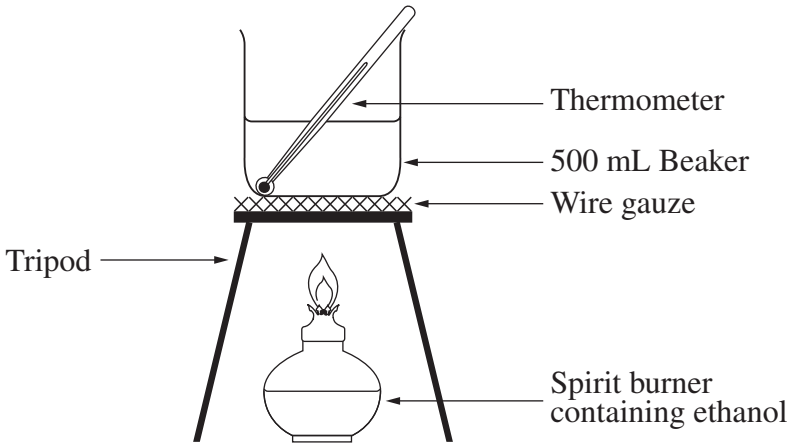
Marks

Question 17 (6 marks)

Students were asked to perform a first-hand investigation to determine the molar heat of combustion of ethanol.

The following extract is from the practical report of one student.

Apparatus used:



Lab data:

Mass of water	=	250.0 g
Initial mass of burner	=	221.4 g
Final mass of burner	=	219.1 g
Initial temperature of water	=	19.0°C
Final temperature of water	=	59.0°C

(a) After completing the calculations correctly, the student found that the answer did not agree with the value found in data books. Suggest ONE reason for this. **1**

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(b) Propose TWO adjustments that could be made to the apparatus or experimental method to improve the accuracy of the results. **2**

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Question 17 continues on page 11

Marks

Question 17 (continued)

(c) Calculate the molar heat of combustion of ethanol, using the student's data. **3**

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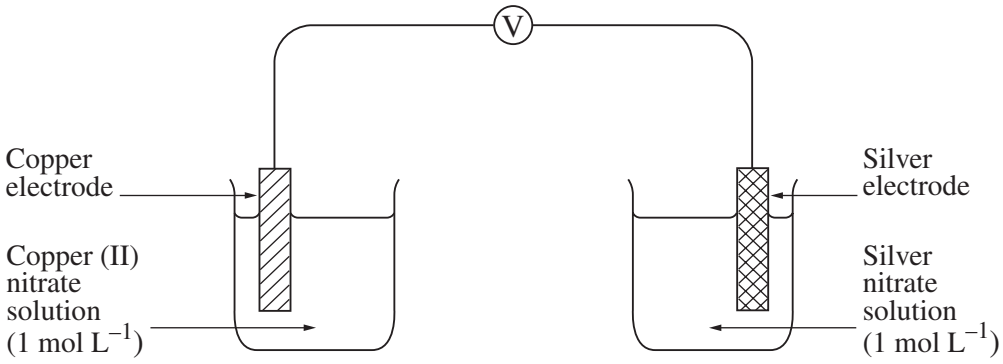
End of Question 17

Please turn over

Marks

Question 18 (6 marks)

A galvanic cell was made by connecting two half-cells. One half-cell was made by putting a copper electrode in a copper (II) nitrate solution. The other half-cell was made by putting a silver electrode in a silver nitrate solution. The electrodes were connected to a voltmeter as shown in the diagram.



(a) Complete the above diagram by drawing a salt bridge. **1**

(b) Using the *standard potentials* table in the data sheet, calculate the theoretical voltage of this galvanic cell. **2**

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(c) A student removes the voltmeter from the circuit and replaces it with an electrical generator. The generator causes the copper electrode to increase in mass. **3**

Explain, using an equation, why the copper electrode will increase in mass.

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Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 19 (7 marks)

Name ONE type of cell, other than the dry cell or lead–acid cell, you have studied. Evaluate it in comparison with either the dry cell or lead–acid cell, in terms of chemistry and the impact on society. Include relevant chemical equations in your answer. **7**

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Marks

Question 20 (4 marks)

A 0.1 mol L^{-1} solution of hydrochloric acid has a pH of 1.0, whereas a 0.1 mol L^{-1} solution of citric acid has a pH of 1.6.

(a) State ONE way in which pH can be measured. **1**

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(b) Explain why the two solutions have different pH values. **3**

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Marks

Question 21 (4 marks)

Barium hydroxide and sulfuric acid react according to the following equation:

$$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$$

(a) Name this type of chemical reaction. **1**

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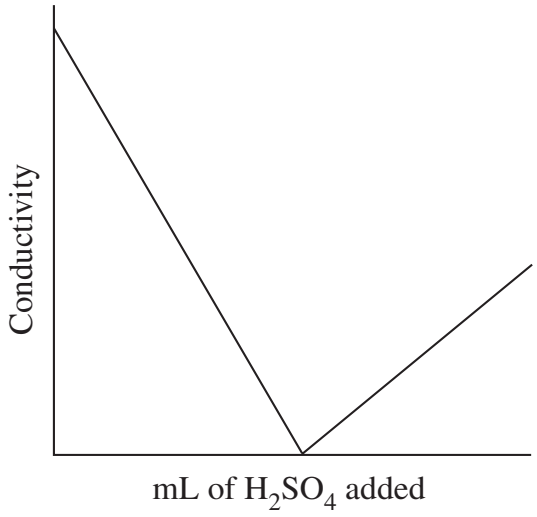
(b) A 20 mL sample of barium hydroxide was titrated with 0.12 mol L^{-1} sulfuric acid. The conductivity of the solution was measured throughout the titration and the results graphed, as shown. **3**



Explain the changes in conductivity shown by the graph.

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Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 22 (6 marks)

Justify the procedure you used to prepare an ester in a school laboratory. Include relevant chemical equations in your answer. **6**

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Marks

Question 23 (4 marks)

A household cleaning agent contains a weak base of general formula NaX. 1.00 g of this compound was dissolved in 100.0 mL of water. A 20.0 mL sample of the solution was titrated with 0.1000 mol L^{-1} hydrochloric acid and required 24.4 mL of the acid for neutralisation.

(a) What is the Brönsted–Lowry definition of a base? **1**

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(b) What is the molar mass of this base? **3**

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Marks

Question 24 (6 marks)

In the early twentieth century, Fritz Haber developed a method for producing ammonia, as shown by the equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) Ammonia is used as a cleaning agent. State ONE other use of ammonia. **1**

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(b) Explain the effect of liquefying the ammonia on the yield of the reaction. **2**

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(c) Explain why it is essential to monitor the temperature and pressure inside the reaction vessel. **3**

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Centre Number

Student Number

Section I – Part B (continued)

Marks

Question 25 (6 marks)

Explain the need for monitoring the products of a chemical reaction such as combustion. **6**

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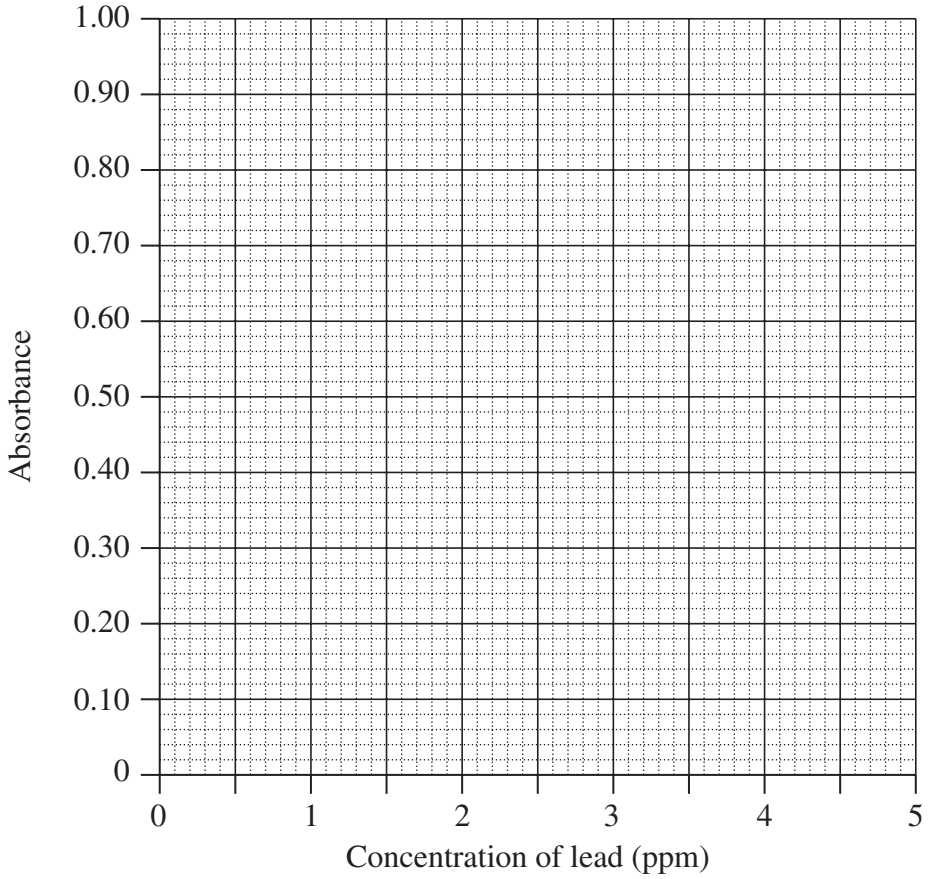
Marks

Question 26 (4 marks)

A university student decided to measure the concentration of lead (Pb) in the soil around his home. He prepared five standard lead solutions of known concentration. The absorbance of these solutions was measured. These results are shown in the table.

Concentration of lead standard (ppm)	*Absorbance*
0	0.00
1	0.15
2	0.31
3	0.44
4	0.59
5	0.75

(a) Draw a line graph of these data. **1**



Question 26 continues on page 23

Question 26 (continued)

(b) The student prepared solutions from four different soil samples around his home. These solutions were also analysed using the same method. The results are shown in the table. **1**

Solutions made from soil samples	
Area sampled	*Absorbance*
Front garden bed	0.19
Back garden bed	0.09
Mail box	0.22
Back fence	0.11

Determine the highest concentration of lead in the soil around the home.

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(c) State an hypothesis to account for the variation in lead concentration around the student's home. **2**

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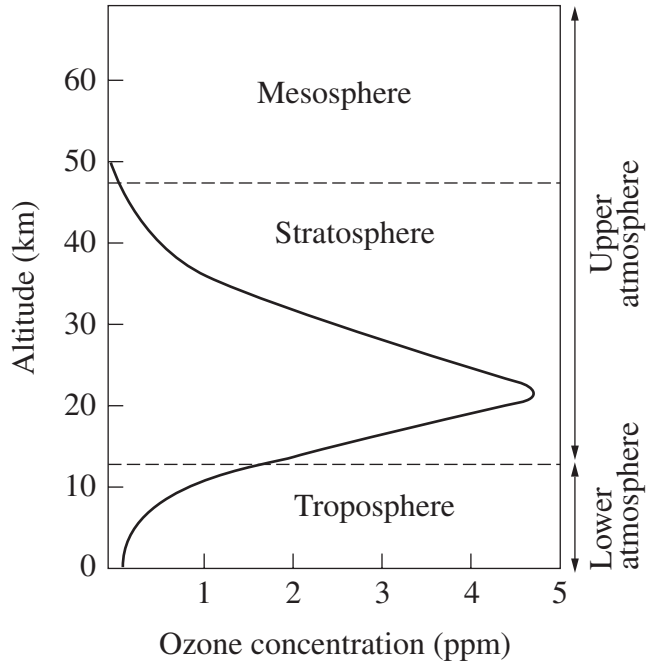
End of Question 26

Please turn over

Marks

Question 27 (4 marks)

Oxygen exists in the atmosphere as the allotropes oxygen and ozone. The graph shows a typical change in ozone concentration with changing altitude. **4**



Compare the environmental effects of the presence of ozone in the upper and lower atmosphere.

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 28–32
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.

Marks

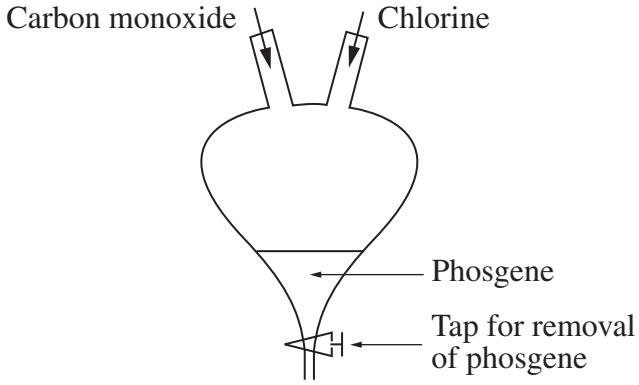
Question 28 — Industrial Chemistry (25 marks)

Electrolysis is an important industrial process.

(a) (i) Define *electrolysis*. **1**

(ii) Compare the reaction products from the electrolysis of molten sodium chloride and concentrated aqueous sodium chloride. **2**

(b) Carbonyl chloride, $COCl_2$, is a colourless, poisonous gas that is also known as phosgene. It is needed for the production of insecticides, polyurethane plastics and polycarbonate. It is produced from the exothermic equilibrium reaction of carbon monoxide gas and chlorine gas. When the reaction vessel is cooled below 8°C the phosgene is a liquid.



Reaction vessel for the formation of phosgene at 4°C

(i) Write a balanced equation for the formation of phosgene. **2**

(ii) Explain how industry could maximise the production of phosgene. **2**

(c) Explain why sulfuric acid is an important industrial chemical. Include balanced chemical equations in your answer. **5**

(d) (i) Name the chemical process used to make soap. **1**

(ii) Outline the procedure for making soap in the school laboratory. **2**

(iii) Describe a safety risk associated with the procedure outlined in part (ii), and suggest a safe work practice to minimise the risk. **3**

(e) Evaluate how environmental issues are addressed in the Solvay process. **7**

Marks

Question 29 — Shipwrecks and Salvage (25 marks)

(a) (i) Identify the main metal used to construct ships. **1**

(ii) Although aluminium is a very reactive metal, with a very low reduction potential, it is used in many structures exposed to oxidising conditions. Explain why aluminium can be used in this way. **2**

(b) (i) Give an example of a metal commonly used as a sacrificial anode. **1**

(ii) Explain why sacrificial anodes are added to metal-hulled ships. **3**

(c) Describe the effect of adding other elements to iron on the properties and uses of steels. **5**

(d) (i) Define *corrosion*. **1**

(ii) Outline a procedure that could be used to compare the corrosion rates of different metals or alloys in the school laboratory. **2**

(iii) Describe ways in which accuracy and reliability could be improved in the procedure described in part (ii). **3**

(e) For ONE specific metal, evaluate the steps that can be used to clean, stabilise and preserve artefacts recovered from shipwrecks. **7**

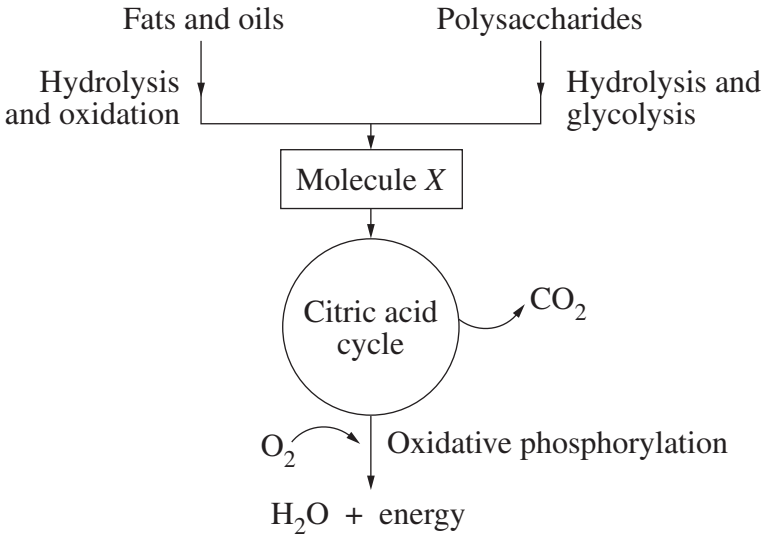
Marks

Question 30 — The Biochemistry of Movement (25 marks)

(a) (i) Name the molecule that stores energy for nearly all metabolic processes. **1**

(ii) Explain how the biologically important part of the molecule in part (i) provides energy for cellular metabolism. **2**

(b) Energy for our bodies to function is provided by the oxidation of fuels. Fats and glucose are used as fuels. A summary of the oxidation of fats and glucose is shown.



(i) Identify molecule *X* and state its function. **2**

(ii) Analyse the role of oxidative phosphorylation in energy production. **2**

(c) Discuss the use of models in developing an understanding of enzyme function. **5**

(d) (i) Define *viscosity*. **1**

(ii) Outline a procedure that could be used to compare the viscosity of pure glycerol and a glycerol solution. **2**

(iii) Describe ways in which accuracy and reliability could be improved in the procedure described in part (ii). **3**

(e) The energy requirements for different types of skeletal muscle are met by the interaction of separate energy output systems. **7**

Analyse the role and interaction of the energy output systems used by skeletal muscle.

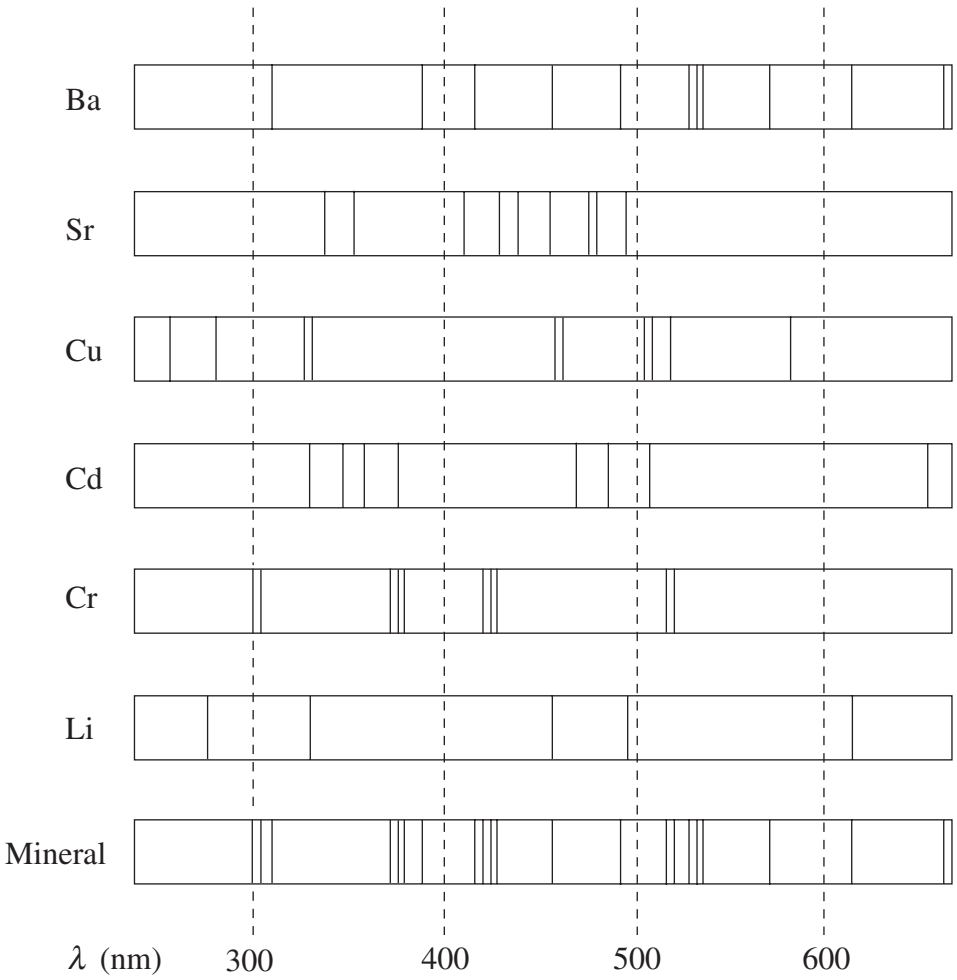
Marks

Question 31 — The Chemistry of Art (25 marks)

(a) (i) Identify the mineral source of a pigment. **1**

(ii) Describe the use of a named separation process to obtain a pigment. **2**

(b) A sample of a mineral used as a pigment was subjected to spectroscopic analysis. The spectrum is shown.



(i) Identify the elements in the mineral sample. **2**

(ii) Explain how a line spectrum is produced. **2**

Question 31 continues on page 30

Marks

Question 31 (continued)

(c) Describe the Bohr model of the atom, and identify ONE merit and ONE limitation of the model. **5**

(d) (i) Name a transition element. **1**

(ii) Outline a first-hand investigation to demonstrate the colour changes of a named transition element as it changes in oxidation state. **2**

(iii) Describe a safety risk associated with the procedure outlined in part (ii), and suggest a safe work practice to minimise the risk. **3**

(e) With reference to TWO pigments, explain how the metallic components produce colour. **7**

End of Question 31

Marks

Question 32 — Forensic Chemistry (25 marks)

(a) (i) Define *organic compounds*. **1**

(ii) For ONE class of organic compound, describe a chemical test that identifies this class. **2**

(b) The table shows fatty acid composition of some common oils and fats.

	Fatty acids present (% by weight)				
Fat or oil hydrolysed	Lauric	Palmitic	Stearic	Oleic	Linoleic
Butter	2–3	23–26	10–13	30–40	4–5
Lard	< 1	28–30	12–18	41–48	6–7
Tallow	< 1	24–32	14–32	35–38	2–4
Coconut	45–51	4–10	1–5	2–10	0–2

An oily sample was hydrolysed and the fatty acids analysed.

	Fatty acids present (% by weight)				
	Lauric	Palmitic	Stearic	Oleic	Linoleic
Oil sample	< 1	29	28	36	4

(i) Which fat or oil has been identified? **1**

(ii) Explain the solubility in water of fatty acids, in terms of their structure. **3**

(c) Assess the usefulness of mass spectrometry in providing forensic evidence. **5**

(d) (i) Name ONE technique used by forensic chemists to separate a mixture of organic compounds. **1**

(ii) In your study of Forensic Chemistry, you performed a first-hand investigation to separate a mixture of organic materials. Outline the procedure. **2**

(iii) Describe ways in which accuracy and reliability could be improved in the procedure described in part (ii). **3**

(e) Discuss the uses of DNA analysis in forensic chemistry. **7**

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Chemistry

DATA SHEET

Avogadro's constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 101.3 kPa (1.00 atm) and

at 273 K (0°C) ..... 22.41 L

at 298 K (25°C) ..... 24.47 L

Ionisation constant for water at 298 K (25°C), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

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

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (4th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	Symbol of element	Name of element
79	Au	Gold
Atomic Weight	197.0	

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.