1994

CHEMISTRY
2 UNIT

NEW SOUTH WALES
HSC TRIAL EXAMINATION
AND SOLUTIONS

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HIGHER SCHOOL CERTIFICATE EXAMINATION

1994
CHEMISTRY
2 UNIT
Section I - Core Trial

(not to be used before Monday July 11, 1994)

Time allowed - Two hours
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

Section I - Core

- ALL questions in Section I are COMPULSORY.
- **Part A** 12 one-mark multiple-choice questions.
  Mark your answers in pencil on the Answer Sheet provided.
- **Part B** 6 three-mark questions.
  Write your answers in the Part B Answer Book.
- **Part C** 6 five-mark questions
  Write your answers in the Part C Answer Book.
- Write your Student Number and Centre Number on each Answer Book.
- You may keep this Question Book, which you may use for rough work.
- Anything written in the Question Book will NOT be marked.

A Periodic Table and Data Sheet are provided with this paper.

SECTION I - CORE

PART A

Questions 1-12 are worth 1 mark each. Attempt ALL questions.

For each question (1-12), choose the best of the four possible answers and indicate your choice by filling in the appropriate space on the Answer Sheet provided.

Fill in only ONE choice for each question, using a pencil.

Do NOT use a ball-point or ink pen.

If you change your mind, erase your first mark completely.

1. When 5 mL of 0.01 mol L^{-1} hydrochloric acid is mixed with 15 mL of 0.03 mol L^{-1} hydrochloric acid, the hydrogen ion concentration (in mol L^{-1}) of the resulting solution is

   (A) 0.045

   (B) 0.035

   (C) 0.025

   (D) 0.015

2. Ammonia reacts with oxygen to produce nitrogen monoxide and water according to the equation:

   $$x\ NH_3 + y\ O_2 = z\ NO + w\ H_2O$$

   The values of x , y , z and w which will balance this equation are respectively

   (A) 2 , 2 , 2 , 3

   (B) 3 , 4 , 3 , 4

   (C) 4 , 5 , 4 , 6

   (D) 5 , 6 , 5 , 7

3. Which one of the following contains only pure substances which are compounds?

   (A) dichloromethane, steam, ammonia, sodium hydroxide.

   (B) carbon monoxide, silver nitrate, sodium chloride, magnesium.

   (C) methane, hydrogen peroxide solution, ice, magnesium chloride.

   (D) water, glucose, carbon dioxide, hydrochloric acid.

4. The isotope of plutonium used to produce energy in nuclear fission reactors is $^{239}Pu_{94}$. The number of electrons in a Pu^{3+} ion of this isotope is

(A) 91

(B) 97

(C) 236

(D) 239

5. When one mole of ethane gas reacts completely with oxygen gas, the products are

(A) 1 mole of carbon dioxide and 1 mole of water.

(B) 2 mole of carbon dioxide and 3 mole of water.

(C) 1 mole of carbon dioxide and 2 mole of water.

(D) 2 mole of carbon dioxide and 4 mole of water.

6. During extraction of zinc from its ores, zinc dust is used to reduce trace quantities of silver ions, that are often present in the solutions, to silver metal.
The equation for the reaction is $Zn(s) + 2Ag^{+}(aq) = Zn^{2+}(aq) + 2Ag(s)$

1.0 mol of zinc dust is added to 30 L of a solution with a silver ion concentration of 0.02 mol L^{-1}. After reaction is complete, the amount of zinc metal unreacted is

(A) 0.1 mol.

(B) 0.4 mol.

(C) 0.5 mol.

(D) 0.7 mol.

7. The columns and rows of 2 elements in the Periodic Table are given below. The elements are not given their normal symbols.

Q. column II , row IV

J. column VII, row II

The formula of the compound formed between element J and element Q is

(A) QJ_2.

(B) Q_2J_2.

(C) QJ.

(D) Q_2J.

8. Which one of the following equations represents an oxidation-reduction reaction?

(A) $Al(OH)_3(s) + 3HCl(aq) = AlCl_3(aq) + 3H_2O(l)$

(B) $Zn(s) + 2H^+(aq) = Zn^{2+}(aq) + H_2(g)$

(C) $Ag^+(aq) + Cl^-(aq) = AgCl(s)$

(D) $CaCO_3(s) = CaO(s) + CO_2(g)$

9. Methyl isocyanate is used in the manufacture of insecticide. Methyl isocyanate contains 42.0% carbon, 5.3% hydrogen, 24.6% nitrogen and 28.1% oxygen by mass. The empirical formula of the compound is

(A) $C_8HN_5O_5$

(B) $C_4H_6N_2O_2$

(C) $C_3H_5N_2O_2$

(D) C_2H_3NO

10. Sulfur trioxide is produced from sulfur dioxide and oxygen according to the equation

$$2SO_2(g) + O_2(g) \overset{\text{catalyst}}{\Leftrightarrow} 2SO_3(g) \quad \Delta H = -198 \text{ kJ mol}^{-1}$$

The equilibrium yield of sulfur trioxide will be **high** under conditions of

(A) high temperature, high pressure and low concentration of sulfur dioxide.

(B) low temperature, high pressure and excess air.

(C) high temperature, low pressure and excess air.

(D) low temperature, low pressure and excess sulfur dioxide.

11. Sulfur trioxide, SO_3, is absorbed in water to form sulfuric acid, H_2SO_4. Assuming complete ionisation of the sulfuric acid, what is the pH of the resulting solution when 0.5 mol of SO_3 is completely absorbed in 100 mL of water?

(A) -log 0.25

(B) -log 0.5

(C) -log 5

(D) -log 10

12. The main type of force holding the molecules of water together in ice (solid water) is

(A) nuclear.

(B) gravitational.

(C) electrostatic.

(D) magnetic.

PART B

Questions 13-18 are worth 3 marks each. Attempt ALL questions.

For each question (13-18), write your answer in the appropriate space in the Answer Book provided.

In questions involving calculations, you are advised to show working, as marks may be awarded for relevant working.

13. Metallic iron can be produced in a spectacular exothermic reaction by mixing aluminium powder with finely divided iron(III) oxide and igniting the mixture using a magnesium fuse. The reaction is called the **thermite** reaction. The heat of reaction is sufficient to produce iron in molten form. The other product in the reaction is aluminium oxide.

(a) Write a balanced equation for the thermite reaction.

(b) In such a reaction, 10 g of iron(III) oxide was mixed with 5 g of aluminium powder and the mixture ignited.

Calculate the mass of iron that could be produced from this reaction.

14. (a) (i) When ammonia gas is dissolved in water, an alkaline solution is produced. Write **one** chemical equation that explains this observation.

(ii) When solid ammonium chloride is dissolved in water an acidic solution is formed. Write **two** chemical equations that explain this observation.

(b) Write down **one** conjugate acid-base pair that occurs in (ii).

15. (a) Ozone, O_3, is one of the most important gases in the atmosphere. It decomposes to form O_2 according to the equation: $2O_3(g) = 3O_2(g)$; $\Delta H = -285$ kJ mol^{-1}.

What is the amount of heat released when 10^{-3} mol of ozone decomposes?

(b) When an electric current is passed through pure oxygen gas in the presence of aluminium metal, an extremely bright flash is produced and a considerable amount of heat. Aluminium burns in pure oxygen according to the equation:

$$4Al(s) + 3O_2(g) = 2Al_2O_3(s) \text{ ; } \Delta H = -3340 \text{ kJ mol}^{-1}$$

How much heat is produced by burning 0.027 g of aluminium in pure oxygen?
(The energy associated with the light is very small and may be disregarded in this calculation)

16. Acetic acid is a weak acid which ionises slightly in aqueous solution according to the equation: $CH_3COOH(aq) \Leftrightarrow H^+(aq) + CH_3COO^-(aq)$

(a) Calculate the equilibrium constant for this equation at 25°C if the equilibrium concentrations are:

$[CH_3COOH] = 10^{-2}$ mol L^{-1} , $[H^+] = [HCOO^-] = 10^{-3.4}$ mol L^{-1}

(b) Sodium acetate is added to this equilibrium mixture at 25°C ,that is, more CH_3COO^- is added. Will the pH of the solution increase or decrease? Explain your answer.

17. Some insects are resistant to DDT because they can convert DDT into another chemical, **X**, which is relatively harmless. Analysis of **X** shows that it consists of 52.9% carbon, 2.5% hydrogen, and the rest chlorine.

(a) What is the empirical formula of **X**.

(b) If the molar mass of **X** is about 320 g, determine the molecular formula of **X**.

18. The species listed in the table are either ions or neutral atoms. They may be in their ground states or excited states.

SPECIES	ATOMIC NUMBER	MASS NUMBER	ELECTRONIC CONFIGURATION
1	2	4	2
2	10	20	2.8
3	17	37	2.8.8
4	20	40	2.8.8
5	20	44	2.8.9.1
6	26	56	2.8.14.2

(a) Which two species represent different elements with similar chemical properties? *Give a reason for your answer.*

(b) Which two species represent different elements within the same period of the periodic table? Give *a reason for your answer.*

(c) Which is the species most likely to emit a photon of energy? *Give a reason for your answer.*

PART C

Questions 19-24 are worth 5 marks each. Attempt ALL questions.

For each question (19-24), write your answer in the appropriate space in the Answer Book provided.

In questions involving calculations, you are advised to show working, as marks may be awarded for relevant working.

19. A student does an experiment to measure the energy content of low alcohol beer.

(a) The ethanol in beer undergoes oxidation in the body. Write a balanced equation for the complete reaction of ethanol, $C_2H_5OH(aq)$, with oxygen to produce carbon dioxide and water.

(b) The student completely oxidised 750 g of beer, with an ethanol content of 2.1% by mass. What mass of ethanol is present in 750 g of beer?

(c) When one mole of ethanol is oxidised completely to carbon dioxide and water, 1370 kJ of energy is released. How much energy would be released in the student's experiment?

(d) List one assumption you have made in your calculation in (c).

20. A laboratory receives a sample of ore containing copper only in the form of copper carbonate, $CuCO_3$. 15.00 g of the ore is reacted with 20.0 mL of 0.250 mol L^{-1} $H_2SO_4(aq)$ and the resultant mixture is allowed to stand until reaction is complete.

(a) Write a balanced equation for the reaction between copper carbonate and sulfuric acid.

(b) How many mole of sulfuric acid was added to the copper ore?

All of the carbon dioxide produced is removed from the solution by heating. The resultant solution is then titrated with a 0.250 mol L^{-1} solution of NaOH(aq), and 20.60 mL of the NaOH solution is required to neutralise exactly the remaining acid.

(c) Explain why the carbon dioxide was removed before adding the sodium hydroxide.

(d) Calculate the mass of copper in the sample of copper ore.
(You may assume that $CuCO_3$ is the only substance in the ore that reacts with the acid.)

21. Methanol, CH_3OH, can be produced commercially by mixing carbon monoxide and hydrogen in a reaction vessel containing a mixture of the metal oxides Cr_2O_3 and ZnO.

In the reaction vessel, equilibrium is reached according to the equation:

$$CO(g) + 2H_2(g) = CH_3OH(g) \; ; \; \Delta H = -91 \text{ kJ mol}^{-1}.$$

For a particular synthesis at temperature T, the equilibrium concentrations of CH_3OH, H_2 and CO in the gas in the reaction vessel were:
$[CH_3OH] = 4.00 \text{ mol L}^{-1}$; $[H_2] = 0.50 \text{ mol L}^{-1}$; $[CO] = 0.30 \text{ mol L}^{-1}$.

(a) Calculate the equilibrium constant for the equation given above.

(b) What is the likely purpose of the mixture of Cr_2O_3 and ZnO in the reaction vessel?

(c) Suggest **two** methods whereby the equilibrium yield of methanol from this process could be increased.

22. The table below shows the melting temperatures (MT) of the elements in the main groups of the Periodic Table. The melting temperatures are given in ^oC at 101.3 kPa.

	MT		**MT**		**MT**		**MT**		**MT**		**MT**		**MT**
Li	180	**Be**	1283	**B**	2030	**C**	3600	**N**	-210	**O**	-218	**F**	-220
Na	98	**Mg**	650	**Al**	660	**Si**	1400	**P**	44	**S**	113	**Cl**	-101
K	63	**Ca**	850	**Ga**	30	**Ge**	940	**As**	820	**Se**	220	**Br**	-7
Rb	39	**Sr**	770	**In**	157	**Sn**	232	**Sb**	630	**Te**	450	**I**	113
Cs	29	**Ba**	710	**Tl**	304	**Pb**	327	**Bi**	271				

(a) On the graph in the answer book, plot the melting temperatures of the row of elements from **Li** to **F**.

(b) On the graph in the answer book, plot the melting temperatures of the column of elements from **F** to **I**.

(c) In terms of the structure and bonding of the elements, explain the shape of the graphs which you obtained.

23. Copper metal reacts with concentrated nitric acid to produce nitrogen dioxide gas according to the equation:

$$Cu(s) + 4HNO_3(aq) = Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

(a) What volume of 14 mol L^{-1} nitric acid would be required to react exactly with 3.0 g of copper according to the above equation?

(b) What volume of nitrogen dioxide gas at 101.3 kPa and 273 K would be produced in this reaction?

(c) Explain why this reaction is an oxidation-reduction reaction.

24. In some early forms of the periodic table based on mass, the element tellurium, with a relative atomic mass of 127.6, was placed one position after iodine which has a relative atomic mass of 126.9. However, in the modern Periodic Table, tellurium is one element position BEFORE iodine.

(a) One isotope of iodine has the structure $_{53}I^{127}$. What do the numbers 53 and 127 tell us about the atomic structure of this isotope of iodine?

(b) Briefly describe the factors which determine the position of an element in the modern Periodic Table.

(c) What does the information given above tell us about the atomic structure of tellurium?

END OF QUESTION BOOKLET

1994 HSC CHEMISTRY TRIAL EXAMINATION (CORE)

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1994 HSC CHEMISTRY 2 UNIT TRIAL EXAMINATION

DATA SHEET

- Values of several numerical constants -

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Boltzmann's constant, k	1.381 x 10-23 J K^{-1}
Elementary charge, e	1.602×10^{-19} C
Faraday constant, F	96 490 C mol^{-1}
Gas constant, R	8.314 J K^{-1} mol^{-1}
	0.0821 L atm K^{-1} mol^{-1}
Ionisation constant for water at 298 K (25^{o}C), K_w	1.0×10^{-14}
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Volume of 1 mole ideal gas at 101.3 kPa (1.00 atm) and	
at 273 K (0^{o}C)	22.41 L
at 298 K (25^{o}C)	24.47 L

- Some standard potentials -

$K^+ + e^-$	↔	K(s)	-2.92 V
$Ba^{2+} + 2e^-$	↔	Ba(s)	-2.90 V
$Ca^{2+} + 2e^-$	↔	Ca(s)	-2.87 V
$Na^+ + e^-$	↔	Na(s)	-2.71 V
$Mg^{2+} + 2e^-$	↔	Mg(s)	-2.36 V
$Al^{3+} + 3e^-$	↔	Al(s)	-1.66 V
$Mn^{2+} + 2e^-$	↔	Mn(s)	-1.18 V
$H_2O + e^-$	↔	$\frac{1}{2} H_2(g) + OH^-$	-0.83 V
$Zn^{2+} + 2e^-$	↔	Zn(s)	-0.76 V
$S(s) + 2e^-$	↔	S^{2-}	-0.48 V
$Fe^{2+} + 2e^-$	↔	Fe(s)	-0.41 V
$Ni^{2+} + 2e^-$	↔	Ni(s)	-0.23 V

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DATA SHEET

- Some standard potentials (continued)

$Sn^{2+} + 2e^-$	↔	$Sn(s)$	-0.14 V
$Pb^{2+} + 2e^-$	↔	$Pb(s)$	-0.13 V
$CO_2(g) + 4H^+ + 4e^-$	↔	$HCHO + H_2O$	-0.07 V
$Fe^{3+} + 3e^-$	↔	$Fe(s)$	-0.02 V
$CO_2(g) + 4H^+ + 4e^-$	↔	$\frac{1}{6} C_6H_{12}O_6$ (glucose) $+ H_2O$	0.01 V
$H^+ + e^-$	↔	$\frac{1}{2} H_2(g)$	0.00 V
$CO_2(g) + 6H^+ + 6e^-$	↔	$CH_3OH + H_2O$	0.03 V
$CO_2(g) + 8H^+ + 8e^-$	↔	$CH_4 + 2H_2O$	0.17 V
$SO_4^{2-} + 4H^+ + 2e^-$	↔	$SO_2(g) + 2H_2O$	0.21 V
$HCHO + 2H^+ + 2e^-$	↔	CH_3OH	0.24 V
$Cu^{2+} + 2e^-$	↔	$Cu(s)$	0.34 V
$\frac{1}{2} O_2(g) + H_2O + 2e^-$	↔	$2OH^-$	0.40 V
$HCHO + 4H^+ + 4e^-$	↔	$CH_4(g) + H_2O$	0.41 V
$NiO_2(s) + 2H_2O + 2e^-$	↔	$Ni(OH)_2(s) + 2OH^-$	0.49 V
$Cu^+ + e^-$	↔	$Cu(s)$	0.52 V
$\frac{1}{2} I_2(s) + e^-$	↔	I^-	0.54 V
$\frac{1}{2} I_2(aq) + e^-$	↔	I^-	0.62 V
$Fe^{3+} + e^-$	↔	Fe^{2+}	0.77 V
$Ag^+ + e^-$	↔	$Ag(s)$	0.80 V
$NO_3^- + 4H^+ + 3e^-$	↔	$NO(g) + 2H_2O$	0.96 V
$\frac{1}{2} Br_2(l) + e^-$	↔	Br^-	1.07 V
$\frac{1}{2} Br_2(aq) + e^-$	↔	Br^-	1.09 V
$\frac{1}{2} O_2(g) + 2H^+ + 2e^-$	↔	H_2O	1.23 V
$\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$	↔	$Cr^{3+} + \frac{7}{2} H_2O$	1.33 V
$\frac{1}{2} Cl_2(g) + e^-$	↔	Cl^-	1.36 V
$\frac{1}{2} Cl_2(aq) + e^-$	↔	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	↔	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2} F_2(g) + e^-$	↔	F^-	2.87 V

Higher School Certificate Core Trial Examination 1994

CENTRE NO.				

DIRECTIONS: Write your Student Number in the slots provided below as indicated by the large arrow. Then, in the column of digits below each box, blacken the circle which has the same number as you have written in the box. Fill in one circle only in each column.

Read each question and its suggested answers. When you have decided which answer is correct, fill in the response circle completely with an ordinary pencil. Mark only one circle per question. If you change your mind, erase your first mark completely, then make a new mark. Make no stray marks, they may count against you. Do not use a ball-point or ink pen.

SAMPLE: Sydney is
A-a country
B-a mountain
C-an island
D-a city

Ⓐ Ⓑ Ⓒ ●

20270 CHEMISTRY - 2 UNIT

PART A - ATTEMPT ALL QUESTIONS

STUDENT NUMBER

①	①	①	①	①	①	①
②	②	②	②	②	②	②
③	③	③	③	③	③	③
④	④	④	④	④	④	④
⑤	⑤	⑤	⑤	⑤	⑤	⑤
⑥	⑥	⑥	⑥	⑥	⑥	⑥
⑦	⑦	⑦	⑦	⑦	⑦	⑦
⑧	⑧	⑧	⑧	⑧	⑧	⑧
⑨	⑨	⑨	⑨	⑨	⑨	⑨
⓪	⓪	⓪	⓪	⓪	⓪	⓪

PART A

1	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12	Ⓐ	Ⓑ	Ⓒ	Ⓓ

STUDENTS SHOULD NOW CONTINUE WITH PART B

STUDENT NUMBER

CENTRE NUMBER

Higher School Certificate Core Trial Examination

1994

CHEMISTRY

2 UNIT

PART B ANSWER BOOK

DIRECTIONS TO CANDIDATES

- Write your Student Number and Centre Number at the top right hand corner of this page.
- You should receive this paper with an Answer Sheet for Part A and a Part C Answer Book.
- Answer Questions 13 to 18 in this Answer Book.
- Each question is worth 3 marks.

EXAMINER'S USE ONLY

PART	Mark	Examiner	Check
B			

Question 13 to 18 (3 marks each)

Write your answer to each question in the appropriate space in this Answer Book.

EXAMINER'S USE ONLY

13. **(a)** .....

(b) .....

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14. **(a)**

(i) .....

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(ii) .....

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(b) .....

EXAMINER'S USE ONLY

15. **(a)** .....

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(b) .....

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EXAMINER'S USE ONLY

16. **(a)** .....

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(b) .....

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17. **(a)** .....

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(b) .....

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EXAMINER'S USE ONLY

18. **(a)** .....

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(b) .....

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(c) .....

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END OF PART B ANSWER BOOK

Higher School Certificate Core Trial Examination

STUDENT NUMBER

CENTRE NUMBER

1994

CHEMISTRY

2 UNIT

PART C ANSWER BOOK

DIRECTIONS TO CANDIDATES

- Write your Student Number and Centre Number at the top right hand corner of this page.
- You should receive this paper with an Answer Sheet for Part A and a Part B Answer Book.
- Answer Questions 19 to 24 in this Answer Book.
- Each question is worth 5 marks.

EXAMINER'S USE ONLY

PART	Mark	Examiner	Check
C			

Question 19 to 24 (5 marks each)

Write your answer to each question in the appropriate space in this Answer Book.

EXAMINER'S USE ONLY

19. **(a)** .....

(b) .....

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(c) .....

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(d) .....

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20. **(a)** .....

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(b) .....

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(c) .....

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EXAMINER'S USE ONLY

20. **(d)** .....

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21. **(a)** .....

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(b) .....

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(c) .....

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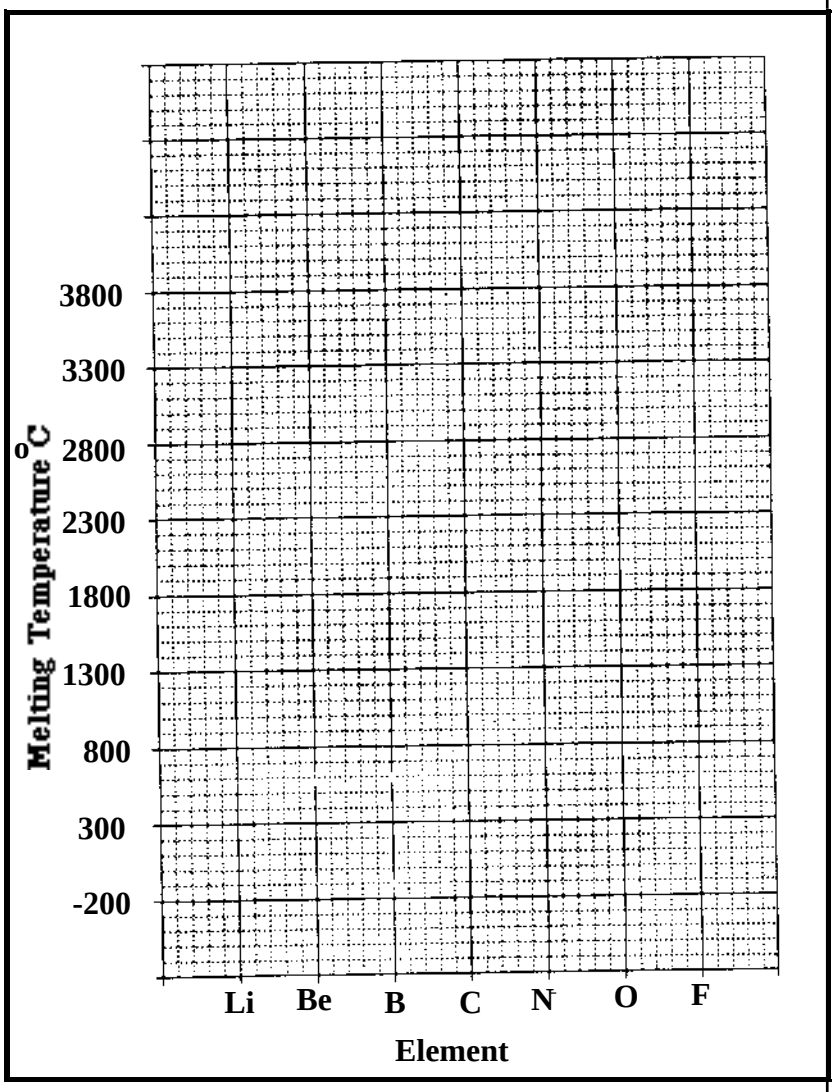
22. (a)



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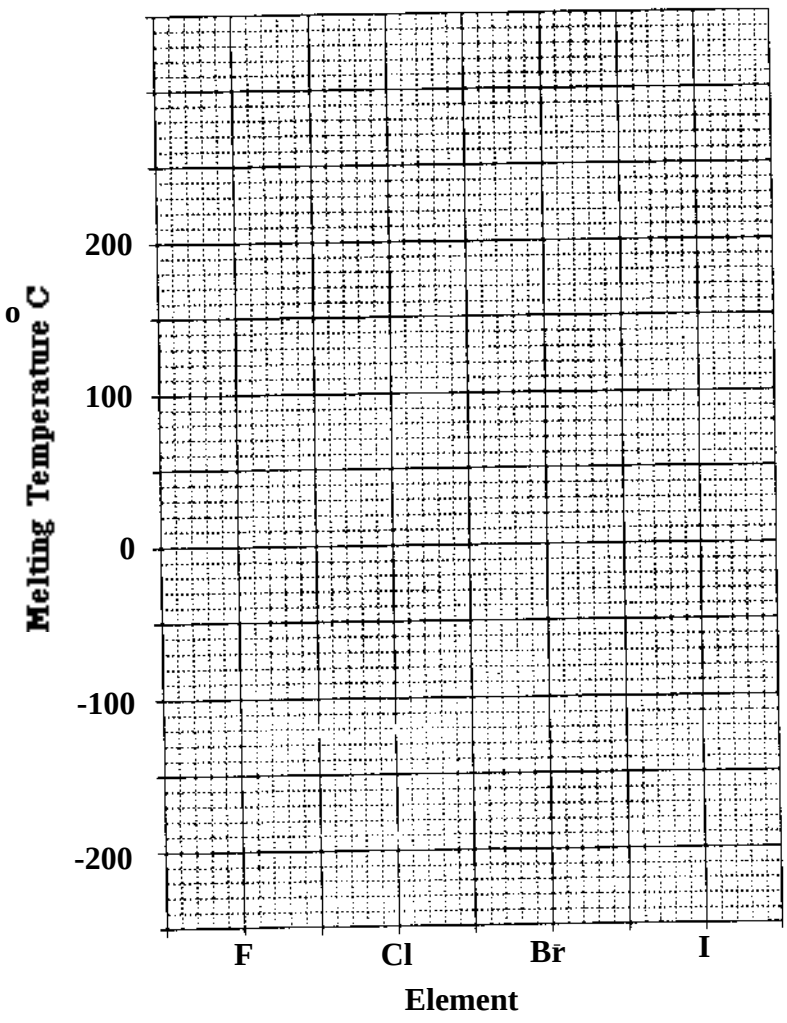
EXAMINER'S USE ONLY

22. (b)



(c) .....

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EXAMINER'S USE ONLY

23. **(a)** .....

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(b) .....

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(c) .....

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EXAMINER'S USE ONLY

24. **(a)** .....

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(b) .....

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(c) .....

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END OF PART C ANSWER BOOK

SECTION 1 - CORE PART A

SUGGESTED SOLUTIONS

1. ANS C

n(HCl) = (0.05 x 0.01) + (0.15 x 0.03) = 0.0005 + 0.0045 = 0.005

$c(H^+) = c(HCl) = 0.005/0.20 = 0.025$ mol L^{-1}.

2. ANS C

This equation will be balanced with $4NH_3$ and 4NO to balance the N atoms; $5O_2$ and $6H_2O$ to balance the O and H.

3. ANS A

Hydrochloric acid is a mixture of hydrogen chloride and water. Magnesium is an element. Hydrogen peroxide solution is a mixture of hydrogen peroxide and water. All of the substances in (A) are pure compounds.

4. ANS A

$^{239}Pu_{94}$ has an atomic number of 94 and a mass number of 239. The number of electrons in a neutral atom is equal to the number of protons. However, in the ion Pu^{3+}, there are three less electrons than in the neutral atom. Therefore, the number of electrons = 94 - 3 = 91.

5. ANS B

The balanced equation for this reaction with one mole of ethane is

$$C_2H_6(g) + \frac{7}{2}O_2(g) = 2CO_2(g) + 3H_2O(g)$$

6. ANS D

The number of mole of $Ag^+(aq)$ = 30 x 0.02 = 0.6 mol. From the balanced equation, 0.3 mol of Zn(s) will react exactly with 0.6 mol of $Ag^+(aq)$. Hence, after the reaction is complete, the amount of Zn(s) remaining = 1.0 - 0.3 = 0.7 mol.

7. ANS A

Element J is fluorine which forms an ion with one negative charge. Element Q is calcium which forms an ion with two positive charges. Hence, the formula is CaF_2 or QJ_2.

8. ANS B

An oxidation-reduction reaction involves a transfer of electrons. This occurs only in (B) in which Zn(s) is the electron donor and $H^+(aq)$ is the electron acceptor.

9. ANS D

$n(C) = \frac{42.0}{12.01} = 3.5$ $n(H) = \frac{5.3}{1} = 5.3$ $n(N) = \frac{24.6}{14.01} = 1.76$ $n(O) = \frac{28.1}{16} = 1.76$

To obtain the simplest whole number ratio, divide each of these by 1.76, and obtain the values 1.99 , 3.01 , 1 , 1 which rounded off gives 2 , 3 , 1 , 1 and therefore, the empirical formula C_2H_3NO.

10. ANS B

For an exothermic reaction producing a smaller number of mole of gas, the yield will be increased with a lower temperature, a higher pressure and an excess of reactant.

SECTION 1 - CORE PART A

SUGGESTED SOLUTIONS

11. ANS D

The equations are $SO_3 + H_2O = H_2SO_4$ and $H_2SO_4 = 2H^+ + SO_4^{2-}$.

Therefore $n(H^+) = 2 \times n(SO_3) = 2 \times 0.5 = 1.0$ mol. Hence, $c(H+) = \frac{1.0}{0.1} = 10$ mol L^{-1}.

Hence, pH = - log 10.

12. ANS C

All chemical bonding is electrostatic in nature. That is, it involves the attraction between positive and negative charges.

SECTION 1 - CORE PART B

13. (a) $Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(l)$

(b) $n(Fe_2O_3) = \frac{10}{160} = 0.0625$ and $n(Al) = \frac{5}{27} = 0.1851$

n(Al) required to react = $2 \times n(Fe_2O_3) = 2 \times 0.0625 = 0.125$

Therefore, the aluminium is in excess.

Hence, $n(Fe) = 2 \times n(Fe_2O_3) = 2 \times 0.0625 = 0.125$

Hence, m(Fe) = 0.125 x 55.9 = 7.0 g **ANS**

14. (a) (i) $NH_3(g) + H_2O(l) = NH_4^+(aq) + OH^-(aq)$

(ii) $NH_4Cl(s) + aq = NH_4^+(aq) + Cl^-(aq)$ **and then**

$NH_4^+(aq) + H_2O(l) = NH_3(aq) + H_3O^+(aq)$

(b) Either $NH_4^+(aq)/NH_3(aq)$ or $H_3O^+(aq)/H_2O(l)$

15. (a) When 2 mol of ozone decomposes according to the equation, 285 kJ is produced. Note that 285 kJ mol^{-1} means 285 kJ per mol of equation **AS WRITTEN**. When 10^{-3} mol of ozone decomposes, the amount of energy produced is

$\frac{285 \times 10^{-3}}{2} = 0.1425$ kJ = 0.143 kJ **ANS**

(b) The number of mol of aluminium = $\frac{m}{M} = \frac{0.027}{27.0} = 0.001$ mol. From the balanced equation, 4 mol of aluminium burning in pure oxygen produces 3340 kJ. Note that 3340 kJ mol^{-1} means 3340 kJ per mol of equation **AS WRITTEN**. When 0.001 mol of aluminium burns, the amount of energy produced is

$3340 \times \frac{0.001}{4} = 0.835$ kJ **ANS**

SUGGESTED SOLUTIONS

16. (a) $K_C = \frac{[H^+]\ [HCOO^-]}{[CH_3COOH]}$

$= \frac{10^{-3.4} \times 10^{-3.4}}{10^{-2}}$

$= 10^{-4.8}$ **ANS**

(b) The addition of CH_3COO^- will shift the position of equilibrium to the left. More CH_3COOH will be produced and H^+ will be used up. Hence, acidity will decrease. Hence, pH will increase. ANS

17. (a) $n(C) = \frac{52.9}{12.01} = 4.405$; $n(H) = \frac{2.5}{1} = 2.5$; $n(Cl) = \frac{44.6}{35.45} = 1.258$

Therefore, (dividing each number by 1.258), the ratio,
n(C) : n(H) : n(Cl) is 3.5 : 2 : 1
The smallest whole number ratio is 7 : 4 : 2.
Hence, the empirical formula is $C_7H_4Cl_2$.

(b) The formula mass of the empirical formula = 84 + 4 + 71 = 159. The molecular formula must a whole number times the empirical formula. Since 159 x 2 = 318 which is approximately equal to 320, the molecular formula must be $C_{14}H_8Cl_4$.

18. (a) Species 1 and 2 are helium and neon respectively. They are both noble gases. They are in the same group in the periodic table and hence, have similar chemical properties.

(b) Species 5 and 6 are calcium and iron respectively. Calcium and iron are both in period 4 of the periodic table. This can also be deduced from the highest number electron shell that is being filled.

(c) Species 5 is a calcium atom in an excited state (2.8.9.1 instead of 2.8.8.2). Hence, it is the most likely species to emit a photon of energy.

SUGGESTED SOLUTIONS

19. (a) $C_2H_5OH(aq) + 3O_2(g) = 2CO_2(g) + 3H_2O(g)$

(b) Mass of ethanol = $\frac{2.1}{100}$ x 750 = 15.75 g **ANS**

(c) Molecular mass of ethanol = (2 x 12) + 5 + 16 + 1 = 46 g mol^{-1}.

Hence, the number of mol of ethanol = $\frac{2.1}{100}$ x $\frac{750}{46}$.

Therefore, the energy produced = $\frac{2.1}{100}$ x $\frac{750}{46}$ x 1370 = 469 kJ **ANS**

(d) The main assumption in the calculation is that the only source of energy in the beer is the ethanol.

20. (a) The balanced equation for the reaction is
$CuCO_3(s) + H_2SO_4(aq) = CuSO_4(aq) + H_2O(l) + CO_2(g)$ . . . . . .(1)

(b) Original number of mole of $H_2SO_4(aq)$ = 0.25 x 0.02 = 0.005 mol **ANS**

(c) Carbon dioxide is removed because it is an acidic oxide and would react with the sodium hydroxide according to the equation:
$CO_2(aq) + 2NaOH(aq) = Na_2CO_3(aq) + H_2O(l)$

(d) The excess sulfuric acid is neutralised by sodium hydroxide according to the equation $H_2SO_4(aq) + 2NaOH(aq) = Na_2SO_4(aq) + 2H_2O(l)$ . . . . . .(2)

Number of mole of $H_2SO_4(aq)$ left over (from equation (2)) = $\frac{1}{2}$ x n(NaOH) reacting

= $\frac{1}{2}$ x 0.25 x 0.02060

= 2.575 x 10^{-3}

Number of mole of $H_2SO_4(aq)$ reacting with $CuCO_3(s)$ = 0.005 - 2.575 x 10^{-3}

= 2.425 x 10^{-3}

Hence, from equation (1) $n(Cu) = n(CuCO_3) = n(H_2SO_4)$ reacting = 2.425 x 10^{-3}

Therefore, mass of copper in ore sample = 2.425 x 10^{-3} x 63.55 = 0.154 g. **ANS**

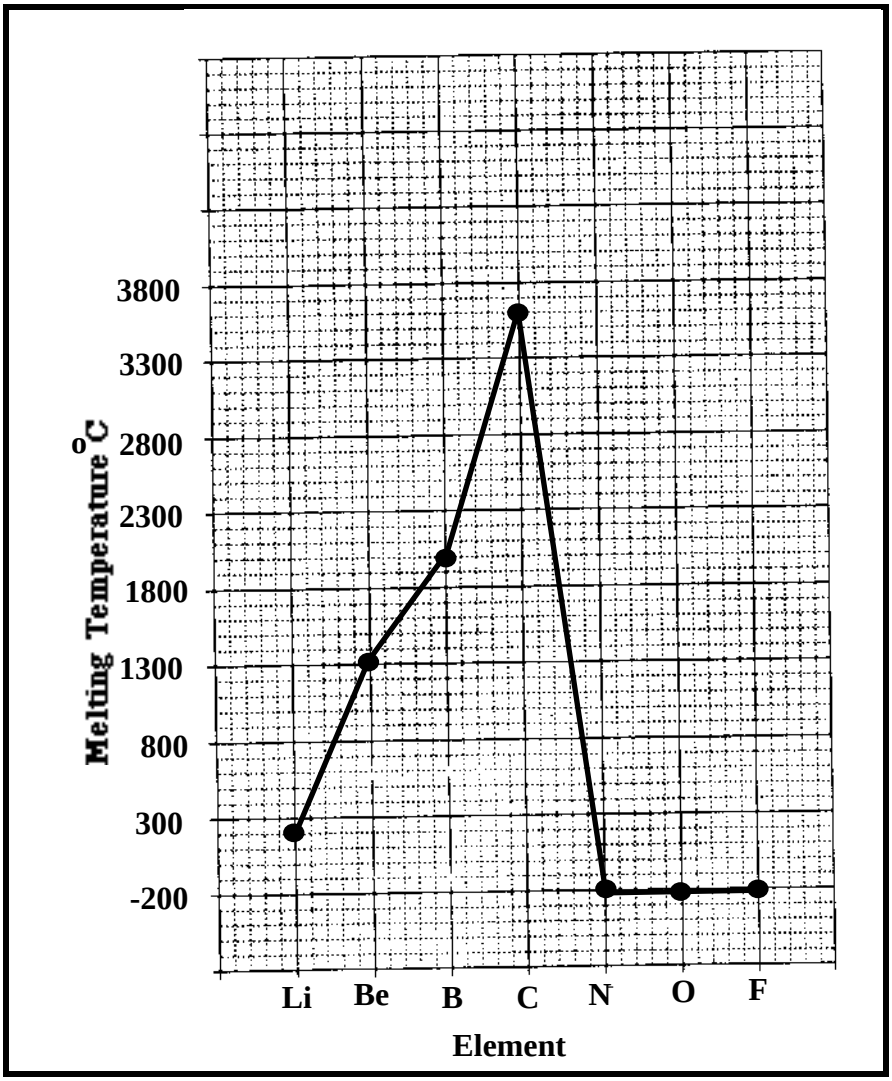
SUGGESTED SOLUTIONS

21. (a) The equilibrium constant = $K = \frac{[CH_3OH]}{[CO]\,[H_2]^2} = \frac{4.00}{0.3 \times (0.5)^2} = 53.3$ **ANS**

(b) The mixture of Cr_2O_3 and ZnO would act as a catalyst. They would increase the rate of both the forward and the reverse reactions thereby enabling equilibrium to be achieved rapidly.

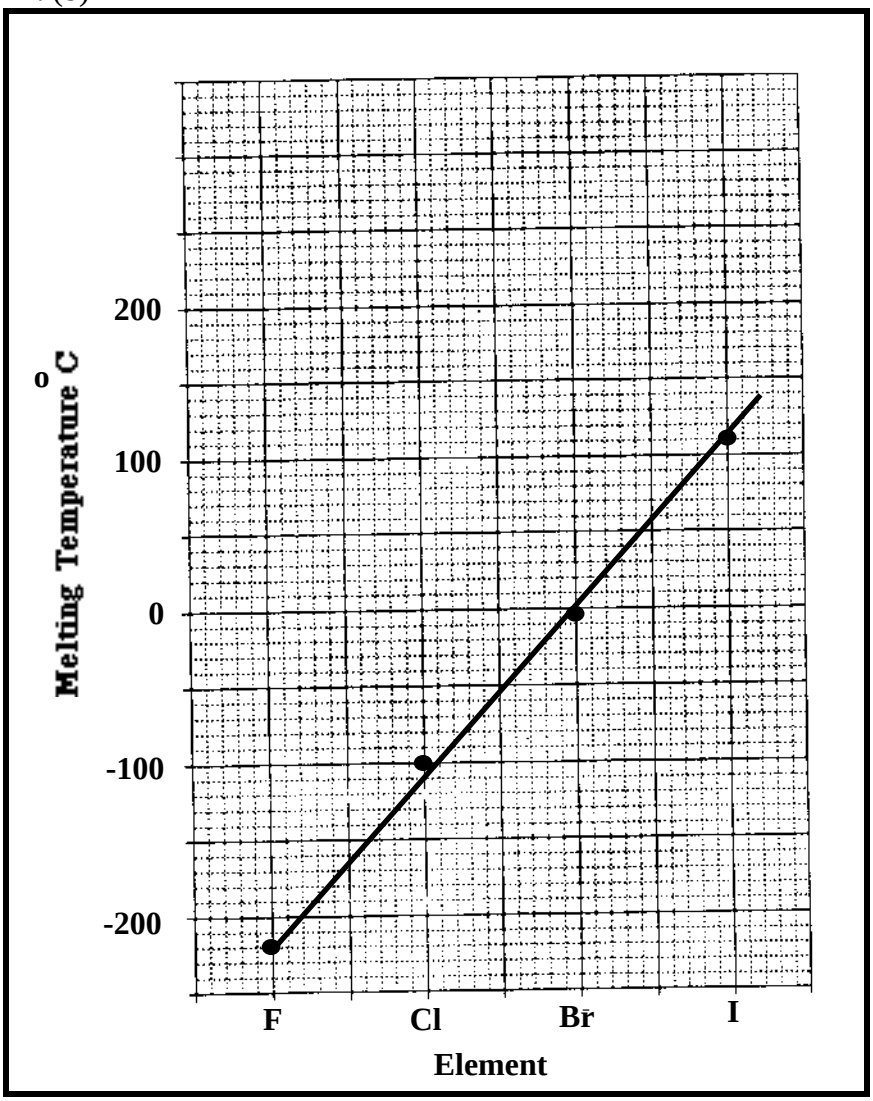
(c) Since the reaction is exothermic, the equilibrium yield of methanol (as well as the equilibrium constant itself) would be increased by lowering the temperature. Since the reaction involves the formation of a smaller number of mole of gas, the equilibrium yield of methanol would be increased by increasing the pressure.

22. (a)



SUGGESTED SOLUTIONS

22. (b)



22. (c) The melting temperatures in the first graph rise to a maximum at the element carbon and then fall away rapidly. The initial increase is due to the increasing covalent nature of the bonding. On the other hand, nitrogen, oxygen and fluorine exist as small covalent molecules with very weak forces of attraction between the molecules. In this series, the structure of the elements changes dramatically from metallic to giant covalent to small individual molecules.
The melting temperatures in the second graph rise steadily. The structure of each of these elements is X_2. As the molecules increase in size from F_2 to I_2, the forces of attraction between the molecules increase and the melting temperature increases.

SUGGESTED SOLUTIONS

23. (a) Number of mole of copper = $\frac{3.0}{63.55}$.

Hence, number of mole of nitric acid required = 4 x $\frac{3.0}{63.55}$. Therefore, volume of nitric acid required = 4 x $\frac{3.0}{63.55}$ x $\frac{1}{14}$ x 1000 mL = 13.5 mL **ANS**

(b) Number of mole of nitrogen dioxide gas produced = 2 x $\frac{3.0}{63.55}$.
Hence, volume of nitrogen dioxide gas under these conditions (assuming an ideal gas) = 2 x $\frac{3.0}{63.55}$ x 22.41 L = 2.1 L **ANS**

(c) This is an oxidation-reduction reaction because the copper metal is acting as an electron donor as it changes from copper metal to copper(II) ions.

24. (a) In a particular iodine atom, there are 53 protons and a total of 127 protons + neutrons. Therefore, there are 74 neutrons in this isotope of iodine.

(b) The elements in the modern Periodic Table are arranged in order of increasing atomic number; that is, in order of the number of protons in the nucleus. When this is done, it is found that elements which exhibit similar chemical properties are in the same group of the Table. It should be noted that historically, elements were placed in groups showing similar chemical properties before anything was known about the internal structure of the atom.

(c) The element tellurium must have an atomic number of 52 since it is one place BEFORE iodine. It can also be said that the element tellurium must have naturally occurring isotopes with larger numbers of neutrons than iodine since the relative atomic mass of tellurium is greater than the relative atomic mass of iodine.

END OF SUGGESTED SOLUTIONS

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PERIODIC TABLE

Key

Atomic Number 79 Au symbol of element

Atomic Mass 197.0 Gold name of element

																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium								1 H 1.008 Hydrogen			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 32.06 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 47.90 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 58.71 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.59 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 Cesium	56 Ba 137.3 Barium	57 La 138.9 Lanthanum	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 226.0 Radium	89 Ac — Actinium	104	105	106												

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 173.0 Ytterbium	71 Lu 175.0 Lutetium
90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np 237.0 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