| Centre Number | Candidate Number | Candidate Name |
|---|---|---|
| | | |

**NAMIBIA SENIOR SECONDARY CERTIFICATE**

# CHEMISTRY ADVANCED SUBSIDIARY LEVEL 8224/2

PAPER 2 Structured Questions 1 hour 15 minutes

Marks 60 **2022**

Additional Materials: Non-programmable calculator
Ruler

## INSTRUCTIONS AND INFORMATION TO CANDIDATES

- Candidates answer on the Question Paper in the spaces provided.
- Write your Centre Number, Candidate Number and Name in the spaces at the top of this page.
- Write in dark blue or black pen.
- You may use a soft pencil for any diagrams, graphs or rough working.
- Do not use correction fluid.
- Do not write in the margin *For Examiner's Use*.
- Answer **all** questions.
- **The Data Booklet is printed on page 13 for your use.**
- The number of marks is given in brackets [ ] at the end of each question or part question.
- A copy of the Periodic Table is printed on page 19.

| For Examiner`s Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| Total | |

| | |
|---|---|
| *Marker* | |
| *Checker* | |



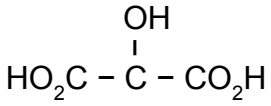
This document consists of **19** printed pages and **1** blank page.

**Republic of Namibia**

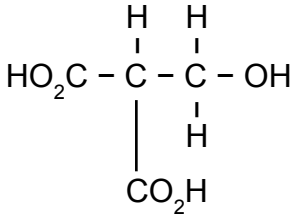
**MINISTRY OF EDUCATION, ARTS AND CULTURE**

*For Examiner's Use*

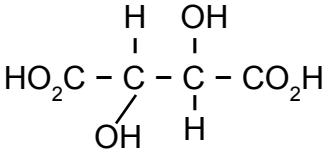
**1** Use the following substances to answer the questions below.



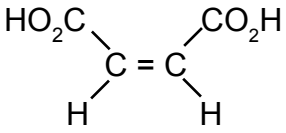
**A**



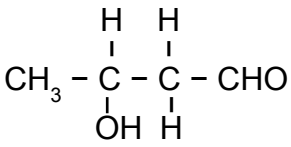
**B**



**C**



**D**



**E**

Each substance can be used once, more than once or not at all.

Identify a substance which;

**(a)** shows geometric isomerism,

..... [1]

**(b)** contains a carbonyl group,

..... [1]

**(c)** reacts with aqueous alkaline iodine to form triodomethane,

..... [1]

**(d)** contains a tertiary alcohol group,

..... [1]

**(e)** forms substance **C** when reacted with cold, dilute acidified manganate(VII) ions,

..... [1]

**(f)** has a group that can be oxidised by $Cr_2O_7^{2-}/H^+$ to form an aldehyde,

..... [1]

**(g)** contains two chiral centres.

..... [1]

[Total: 7]

*For Examiner's Use*

**2** Ammonium nitrate can be used as an explosive. At 500°C ammonium nitrate decomposes to form nitrogen, oxygen and water vapour.

**(a)** Calculate the volume occupied by a single large ammonium nitrate crystal which has a mass of 3.50 g.
The density of ammonium nitrate is 1.75 g / $cm^3$.

..... [1]

**(b)** **(i)** Write a balanced equation for the decomposition of ammonium nitrate.

.....

..... [1]

**(ii)** How many moles of gas are produced by one mole of ammonium nitrate?

..... [1]

**(iii)** Calculate the number of moles of gas produced by the decomposition of 3.50 g of ammonium nitrate.

moles = ..... [2]

**(iv)** Use your answer to **(b)(iii)** to calculate the volume occupied by the gases at 500°C and atmospheric pressure (101kPa).

volume = ..... [2]

*For Examiner's Use*

**(c)** Ammonium nitrate is used in farming.

**(i)** Explain the importance of ammonium compounds in farming.

.....

.....

.....

..... [2]

**(ii)** Give **two** environmental consequences of the uncontrolled use of ammonium compounds.

.....

.....

.....

..... [2]

[Total: 11]

**3** Sodium chloride dissolves in water.

$$NaCl(s) + (aq) \rightarrow Na^{+}(aq) + Cl^{-}(aq) \quad \Delta H = +3.90 \text{ kJ mol}^{-1}$$

**(a)** State and explain whether this reaction is endothermic or exothermic.

.....

..... [1]

**(b)** Dissolving can be considered as a two step process.

**Step 1** Dissociation of the crystal lattice to form separate gaseous ions.

**Step 2** Hydration of the gaseous ions.

**(i)** Define *enthalpy change of solution* ($\Delta H_{sol}$).

.....

..... [1]

**(ii)** Define *enthalpy change of hydration* ($\Delta H_{hyd}$).

.....

..... [1]

**(c)** The enthalpy change of reaction for **Step 1** in **(b)** can be calculated using Hess's Law.

**(i)** Explain why Hess's Law is used to determine some $\Delta H$ values.

.....

..... [1]

**(ii)** The reaction equation for **Step 1** is

$$NaCl(s) \rightarrow Na^+(g) + Cl^-(g).$$

By means of a fully labelled Hess' cycle, calculate the enthalpy change of reaction for **Step 1**.

Use the following data:

$\Delta H_{hyd}$ ($Na^+$) = -406 kJ mol$^{-1}$

$\Delta H_{hyd}$ ($Cl^-$) = -363 kJ mol$^{-1}$

$\Delta H_{sol}$ ($NaCl$) = +3.90 kJ mol$^{-1}$

$\Delta H$ =..... kJmol$^{-1}$ [4]

[Total: 8]

*For Examiner's Use*

**4** Ammonia is synthesised from its elements using the Haber process.

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

**(a)** State the **three** usual operating conditions used in the Haber process.

.....

.....

..... [2]

**(b)** Under certain conditions the partial pressures of the three gases at equilibrium are

| gas | partial pressure |
|---|---|
| $NH_3$ | $2.46 \times 10^3$ kPa |
| $H_2$ | $1.39 \times 10^3$ kPa |
| $N_2$ | $8.98 \times 10^3$ kPa. |

Write an expression for the equilibrium constant, $K_p$, for the Haber process.

[1]

**(ii)** Calculate $K_p$ for the process.

[2]

**(c)** What changes, if any, will occur to the equilibrium position if the partial pressure of hydrogen is raised, while the total pressure and temperature are kept constant?

.....

..... [1]

[Total: 6]

**5** This question is about the properties and reactions of Group 2 metals and their compounds.

**(a)** State the name given to Group 2 metals.

..... [1]

**(b)** Fig. 5.1 shows a reaction scheme that shows reactions of some compounds of magnesium.

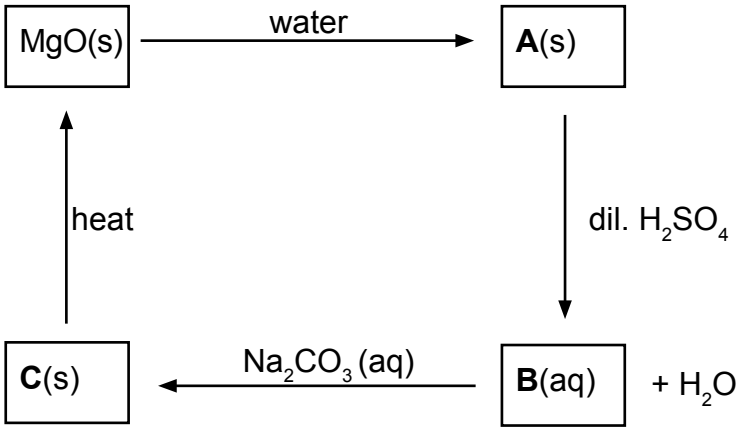



**Fig. 5.1**

**(i)** Identify compounds **A** to **C**.

**A** .....

**B** .....

**C** ..... [3]

**(ii)** Construct balanced equations, including state symbols for the following reactions.

MgO to compound **A**,

..... [1]

compound **B** to compound **C**,

..... [1]

compound **C** to MgO.

..... [1]

**(iii)** Explain the use of compound **A** as a component of medicines taken to relieve acid indigestion or heartburn.

.....

.....

.....

..... [2]

**(c)** Group 2 nitrates decompose when heated.

**(i)** State **one** observation you would make during the decomposition of strontium nitrate, $Sr(NO_3)_2$.

..... [1]

**(ii)** Write a balanced equation for the reaction in **(c) (i)**.

..... [2]

**(iii)** Describe the relative stability of Group 2 nitrates.

.....

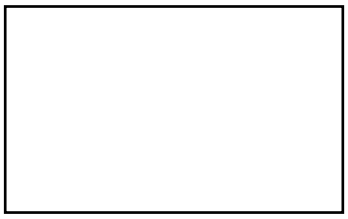
..... [1]

[Total: 13]

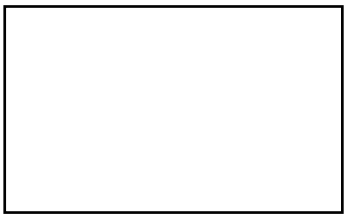
*For Examiner's Use*

**6** Ethane and ethene are hydrocarbons. Their properties are characteristic of other alkanes and alkenes.

**(a)** Give the skeletal formulae of ethane and ethene.



ethane



ethene

[2]

**(b)** Write equations for the following reactions,

**(i)** ethane and bromine in the presence of sunlight,

..... [1]

**(ii)** incomplete combustion of ethane.

..... [1]

**(c)** **(i)** Write the equation for the reaction between steam and ethene.

..... [1]

**(ii)** State the type of organic reaction that occurs when steam reacts with ethene.

..... [1]

**(iii)** Ethene reacts with bromine.

$$CH_2CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$$

Draw diagrams to show the mechanism of this reaction.
You should include relevant dipoles, lone pairs and curly arrows.

[3]

*For Examiner's Use*

**(d) (i)** When but-1-ene reacts with steam, **two** products are formed.
Name the products formed.

1 .....

2 ..... [2]

**(ii)** Suggest the major product in **(c)(iii)**. Name the rule you used to arrive at your answer.

.....

.....

.....

..... [2]

**(iii)** The positional isomer of but-1-ene exists as a pair of stereoisomers
Draw the structure of one of the two stereoisomers.
Give the full name of this isomer.

Name .....

[2]

[Total: 15]

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# DATA BOOKLET

## 1 Important values, constants and standards

| | |
|---|---|
| Molar gas constant | $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$ |
| Avogadro constant | $L = 6.02 \times 10^{23}\ \text{mol}^{-1}$ |
| molar volume of gas | $V_m = 22.4\ \text{dm}^3\ \text{mol}^{-1}$ at s.t.p<br>$V_m = 24.0\ \text{dm}^3\ \text{mol}^{-1}$ under room conditions<br>(where s.t.p is expressed as 101 kPa, approximately, and 273 K (0 °C)) |
| ionic product of water | $K_w = 1.00 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}$<br>(at 298 K (25 °C)) |
| specific heat capacity of water | $= 4.18\ \text{kJ kg}^{-1}\ \text{K}^{-1}$<br>$(= 4.18\ \text{J g}^{-1}\ \text{K}^{-1})$ |

**2 Ionisation energies (1st, 2nd, 3rd and 4th) of selected elements in kJ mol$^{-1}$**

| element | proton number | first | second | third | fourth |
|---|---|---|---|---|---|
| H | 1 | 1310 | - | - | - |
| He | 2 | 2370 | 5250 | - | - |
| Li | 3 | 519 | 7300 | 11 800 | - |
| Be | 4 | 900 | 1760 | 14 800 | 21 000 |
| B | 5 | 799 | 2420 | 3660 | 25 000 |
| C | 6 | 1090 | 2350 | 4610 | 6220 |
| N | 7 | 1400 | 2860 | 4590 | 7480 |
| O | 8 | 1310 | 3390 | 5320 | 7450 |
| F | 9 | 1680 | 3370 | 6040 | 8410 |
| Ne | 10 | 2080 | 3950 | 6150 | 9290 |
| Na | 11 | 494 | 4560 | 6940 | 9540 |
| Mg | 12 | 736 | 1450 | 7740 | 10 500 |
| A*l* | 13 | 577 | 1820 | 2740 | 11 600 |
| Si | 14 | 786 | 1580 | 3230 | 4360 |
| P | 15 | 1060 | 1900 | 2920 | 4960 |
| S | 16 | 1000 | 2260 | 3390 | 4540 |
| C*l* | 17 | 1260 | 2300 | 3850 | 5150 |
| Ar | 18 | 1520 | 2660 | 3950 | 5770 |
| K | 19 | 418 | 3070 | 4600 | 5860 |
| Ca | 20 | 590 | 1150 | 4950 | 6480 |
| Sc | 21 | 632 | 1240 | 2390 | 7110 |
| Ti | 22 | 661 | 1310 | 2720 | 4170 |
| V | 23 | 648 | 1370 | 2870 | 4600 |
| Cr | 24 | 653 | 1590 | 2990 | 4770 |
| Mn | 25 | 716 | 1510 | 3250 | 5190 |
| Fe | 26 | 762 | 1560 | 2960 | 5400 |
| Co | 27 | 757 | 1640 | 3230 | 5100 |
| Ni | 28 | 736 | 1750 | 3390 | 5400 |
| Cu | 29 | 745 | 1960 | 3350 | 5690 |
| Zn | 30 | 908 | 1730 | 3828 | 5980 |
| Ga | 31 | 577 | 1980 | 2960 | 6190 |
| Br | 35 | 1140 | 2080 | 3460 | 4850 |
| Rb | 37 | 403 | 2632 | 3900 | 5080 |
| Sr | 38 | 548 | 1060 | 4120 | 5440 |
| Ag | 47 | 731 | 2074 | 3361 | - |
| I | 53 | 1010 | 1840 | 2040 | 4030 |
| Cs | 55 | 376 | 2420 | 3300 | - |
| Ba | 56 | 502 | 966 | 3390 | - |

## 3 Bond energies

### (a) Bond energies in diatomic molecules (these are exact values)

*Homonuclear*

| Bond | Energy (kJ mol$^{-1}$) |
|---|---|
| H−H | 436 |
| D−D | 442 |
| N≡N | 944 |
| O=O | 496 |
| P≡P | 485 |
| S=S | 425 |
| F−F | 158 |
| C*l*−C*l* | 242 |
| Br−Br | 193 |
| I−I | 151 |

*Heteronuclear*

| Bond | Energy (kJ mol$^{-1}$) |
|---|---|
| H−F | 562 |
| H−C*l* | 431 |
| H−Br | 366 |
| H−I | 299 |
| C≡O | 1077 |

### (b) Bond energies in polyatomic molecules (these are average values)

*Homonuclear*

| Bond | Energy (kJmol−1) |
|---|---|
| C−N | 350 |
| C=C | 610 |
| C≡N | 840 |
| benzene | 520 |
| N−N | 160 |
| N=N | 410 |
| O−O | 150 |
| Si−Si | 222 |
| P−P | 200 |
| S−S | 264 |

*Heteronuclear*

| Bond | Energy (kJmol−1) |
|---|---|
| C−H | 410 |
| C−C*l* | 340 |
| C−Br | 280 |
| C−I | 240 |
| C−N | 305 |
| C=N | 610 |
| C≡N | 890 |
| C−O | 360 |
| C=O | 740 |
| C=O in $CO_2$ | 805 |
| N−H | 390 |
| N−Cl | 310 |
| O−H | 460 |
| Si−C*l* | 359 |
| Si−H | 320 |
| Si−O in $SiO_2$ (s) | 460 |
| Si=O in $SiO_2$ (g) | 640 |
| P−H | 320 |
| P−C*l* | 330 |
| P−O | 340 |
| P=O | 540 |
| S−H | 347 |
| S−C*l* | 250 |
| S−O | 360 |
| S=O | 500 |

## 4 Atomic and ionic radii

| (a) Period 1 | atomic/nm | ionic/nm |
|---|---|---|
| single covalent | H 0.037 | $H^-$ 0.208 |
| van der Waals | He 0.140 | |
| **(b) Period 2** | | |
| metallic | Li 0.152 | $Li^+$ 0.060 |
| | Be 0.112 | $Be^{2+}$ 0.031 |
| | | |
| single covalent | B 0.080 | $B^{3+}$ 0.020 |
| | C 0.077 | $C^{4+}$ 0.015 $C^{4-}$ 0.260 |
| | N 0.074 | $N^{3-}$ 0.171 |
| | O 0.073 | $O^{2-}$ 0.140 |
| | F 0.072 | $F^-$ 0.136 |
| | | |
| van der Waals | Ne 0.160 | |
| **(c) Period 3** | | |
| metallic | Na 0.186 | $Na^+$ 0.095 |
| | Mg 0.160 | $Mg^{2+}$ 0.065 |
| | Al 0.143 | $Al^{3+}$ 0.050 |
| | | |
| single covalent | Si 0.117 | $Si^{4+}$ 0.041 |
| | P 0.110 | $P^{3-}$ 0.212 |
| | S 0.104 | $S^{2-}$ 0.184 |
| | Cl 0.099 | $Cl^-$ 0.181 |
| | | |
| van der Waals | Ar 0.190 | |
| **(d) Group 2** | | |
| metallic | Be 0.112 | $Be^{2+}$ 0.031 |
| | Mg 0.160 | $Mg^{2+}$ 0.065 |
| | Ca 0.197 | $Ca^{2+}$ 0.099 |
| | Sr 0.215 | $Sr^{2+}$ 0.113 |
| | Ba 0.217 | $Ba^{2+}$ 0.135 |
| | Ra 0.220 | $Ra^{2+}$ 0.140 |
| **(e) Group 14** | | |
| single covalent | C 0.077 | |
| | Si 0.117 | $Si^{4+}$ 0.041 |
| | Ge 0.122 | $Ge^{2+}$ 0.093 |
| | | |
| metallic | Sn 0.162 | $Sn^{2+}$ 0.112 |
| | Pb 0.175 | $Pb^{2+}$ 0.120 |

| **(f) Group 17** | | | | | |
|---|---|---|---|---|---|
| single covalent | F | 0.072 | $F^-$ | 0.136 | |
| | C*l* | 0.099 | $Cl^-$ | 0.181 | |
| | Br | 0.114 | $Br^-$ | 0.195 | |
| | I | 0.133 | $I^-$ | 0.216 | |
| | At | 0.140 | | | |
| **(g) first row transition elements (d-block)** | | | | | |
| metallic | Sc | 0.164 | | | $Sc^{3+}$ 0.081 |
| | Ti | 0.146 | $Ti^{2+}$ | 0.090 | $Ti^{3+}$ 0.067 |
| | V | 0.135 | $V^{2+}$ | 0.079 | $V^{3+}$ 0.064 |
| | Cr | 0.129 | $Cr^{2+}$ | 0.073 | $Cr^{3+}$ 0.062 |
| | Mn | 0.132 | $Mn^{2+}$ | 0.067 | $Mn^{3+}$ 0.062 |
| | Fe | 0.126 | $Fe^{2+}$ | 0.061 | $Fe^{3+}$ 0.055 |
| | Co | 0.125 | $Co^{2+}$ | 0.078 | $Co^{3+}$ 0.053 |
| | Ni | 0.124 | $Ni^{2+}$ | 0.070 | |
| | Cu | 0.128 | $Cu^{2+}$ | 0.073 | |
| | Zn | 0.135 | $Zn^{2+}$ | 0.075 | |

**5 Characteristic infra-red absorption frequencies for some selected bonds**

| **Bond** | **Functional groups containing the bond** | **Absorption range (in wavenumbers) / $cm^{-1}$** | **Appearance of peak (s = strong, w = weak)** |
|---|---|---|---|
| C-O | alcohols, ethers, esters | 1040–1300 | ***s*** |
| C=C | alkenes | 1500–1680 | ***w*** unless conjugated |
| C=O | amides<br>ketones and aldehydes<br>carboxylic acids<br>esters | 1640–1690<br>1670–1740<br>1680–1730<br>1710–1750 | ***s***<br>***s***<br>***s***<br>***s*** |
| C-H | alkanes, $CH_2$-H<br>alkenes | 2850–2950<br>3000–3100 | ***s***<br>***w*** |
| N-H | amides, amines | 3300–3500 | ***w*** |
| O-H | carboxylic acids, $RCO_2$-H<br>H-bonded alcohol, RO-H<br>free alcohol, RO-H | 2500–3000<br>3200–3600<br>3580–3650 | ***s*** and very broad<br>***s***<br>***s*** and sharp |

## The Periodic Table of the Elements

**Group**

| 1 | 2 | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1.0 **H** Hydrogen 1 | | | | | | | | | | 4.0 **He** Helium 2 |
| 6.9 **Li** Lithium 3 | 9.0 **Be** Beryllium 4 | | | | | | | | | | | 10.8 **B** Boron 5 | 12.0 **C** Carbon 6 | 14.0 N Nitrogen 7 | 16.0 **O** Oxygen 8 | 19.0 **F** Fluorine 9 | 20.2 **Ne** Neon 10 |
| 23.0 **Na** Sodium 11 | 24.3 **Mg** Magnesium 12 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 27.0 **Al** Aluminium 13 | 28.1 **Si** Silicon 14 | 31.0 **P** Phosphorus 15 | 32.1 **S** Sulfur 16 | 35,5 **Cl** Chlorine 17 | 39.9 **Ar** Argon 18 |
| 39.1 **K** Potassium 19 | 40.1 **Ca** Calcium 20 | 45.0 **Sc** Scandium 21 | 47.9 **Ti** Titanium 22 | 50.9 **V** Vanadium 23 | 52.0 **Cr** Chromium 24 | 54.9 **Mn** Manganese 25 | 55.8 **Fe** Iron 26 | 58.9 **Co** Cobalt 27 | 58.7 **Ni** Nickel 28 | 63.5 **Cu** Copper 29 | 65.4 **Zn** Zinc 30 | 69.7 **Ga** Gallium 31 | 72.6 **Ge** Germanium 32 | 74.9 **As** Arsenic 33 | 79.0 **Se** Selenium 34 | 79.9 **Br** Bromine 35 | 83.8 **Kr** Krypton 36 |
| 85.5 **Rb** Rubidium 37 | 87.6 **Sr** Strontium 38 | 88.9 **Y** Yttrium 39 | 91.2 **Zr** Zirconium 40 | 92.9 **Nb** Niobium 41 | 95.9 **Mo** Molybdenum 42 | - **Tc** Technetium 43 | 101.1 **Ru** Ruthenium 44 | 102.9 **Rh** Rhodium 45 | 106.4 **Pd** Palladium 46 | 107.9 **Ag** Silver 47 | 112.4 **Cd** Cadmium 48 | 114.8 **In** Indium 49 | 118.7 **Sn** Tin 50 | 121.8 **Sb** Antimony 51 | 127.6 **Te** Tellurium 52 | 126.9 **I** Iodine 53 | 131.3 **Xe** Xenon 54 |
| 132.9 **Cs** Caesium 55 | 137.3 **Ba** Barium 56 | 138.9 **La** Lanthanum 57 * | 178.5 **Hf** Hafnium 72 | 180.9 **Ta** Tantalum 73 | 183.8 **W** Tungsten 74 | 186.2 **Re** Rhenium 75 | 190.2 **Os** Osmium 76 | 192.2 **Ir** Iridium 77 | 195.1 **Pt** Platinum 78 | 197.0 **Au** Gold 79 | 200.6 **Hg** Mercury 80 | 204.4 **Tl** Thallium 81 | 207.2 **Pb** Lead 82 | 209.0 **Bi** Bismuth 83 | - **Po** Polonium 84 | - **At** Astatine 85 | - **Rn** Radon 86 |
| - **Fr** Francium 87 | - **Ra** Radium 88 | actinoids 89 – 103 | - **Rf** Rutherfordium 104 | - **Db** Dubnium 105 | - **Sg** Seaborgium 106 | - **Bh** Bohrium 107 | - **Hs** Hassium 108 | - **Mt** Meitnerium 109 | - **Ds** Darmstadtium 110 | - **Rg** Roentgenium 111 | - **Cn** Copernicium 112 | | - **Fl** Flerovium 114 | | - **Lv** Livermorium 116 | | |

**Key**

A = relative atomic mass
**X** = atomic symbol
z = proton (atomic) number

| * | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lanthanoid | 140.1 **Ce** Cerium 58 | 140.9 **Pr** Praseodymium 59 | 144.4 **Nd** Neodymium 60 | - **Pm** Promethium 61 | 150.4 **Sm** Samarium 62 | 152.0 **Eu** Europium 63 | 157.3 **Gd** Gadolinium 64 | 158.9 **Tb** Terbium 65 | 162.5 **Dy** Dysprosium 66 | 164.9 **Ho** Holmium 67 | 167.3 **Er** Erbium 68 | 168.9 **Tm** Thulium 69 | 173.1 **Yb** Ytterbium 70 | 175.0 **Lu** Lutetium 71 |
| Actinoid | 232.0 **Th** Thorium 90 | 231.0 **Pa** Protactinium 91 | 238.0 **U** Uranium 92 | - **Np** Neptunium 93 | - **Pu** Plutonium 94 | - **Am** Americium 95 | - **Cm** Curium 96 | - **Bk** Berkelium 97 | - **Cf** Californium 98 | - **Es** Einsteinium 99 | - **Fm** Fermium 100 | - **Md** Mendelevium 101 | - **No** Nobelium 102 | - **Lr** Lawrencium 103 |

The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.).

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