NAMIBIA SENIOR SECONDARY CERTIFICATE

CHEMISTRY ADVANCED SUBSIDIARY LEVEL 8224/1

PAPER 1 Multiple Choice 1 hour

Marks 40 **2022**

Additional Materials: Multiple choice answer sheet
Non-programmable calculator
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS AND INFORMATION TO CANDIDATES

- Write in soft pencil.
- Make sure that you receive the multiple choice answer sheet with **your examination number** on it.

- There are **forty** questions on this paper. Answer **all** questions.
- For each question, there are four possible answers **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the separate answer sheet.
- If you want to change an answer, thoroughly erase the one you wish to delete.
- The Periodic Table is printed on page 19.
- **The Data Booklet is printed on page 13 for your use.**

- **Read the instructions on the answer sheet carefully.**

- Each correct answer will score one mark.
- Any rough working should be done in this booklet.
- All questions in this paper carry equal marks.
- You may use a non-programmable calculator.

This document consists of **18** printed pages and **2** blank pages.

Republic of Namibia

MINISTRY OF EDUCATION, ARTS AND CULTURE

1 What is the electron configuration of an aluminium ion, Al^{3+}?

A $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

B $1s^2\ 2s^2\ 3p^5$

C $1s^2\ 2s^2\ 2p^6$

D $1s^2\ 2s^2\ 2p^6\ 3s^3$

2 During the extraction of uranium from its ore, insoluble ammonium diuranate, $(NH_4)_2U_2O_7$, is converted into yellowcake, which is later refined into uranium.

What is the percentage of uranium in ammonium diuranate?

A 38.1

B 39.3

C 76.3

D 78.5

3 Which fuel releases the greatest volume of carbon dioxide when one mole of fuel is completely burned in air?

A butanol

B ethanol

C methane

D propane

4 Which gas is classified as non-flammable and non-poisonous?

A ammonia

B carbon monoxide

C methane

D oxygen

5 What is an assumption of the ideal gas equation, pV = nRT?

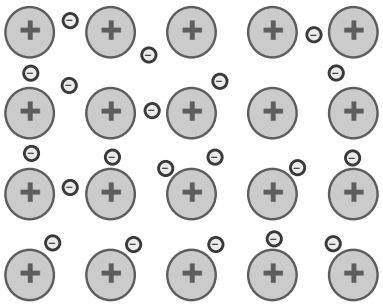
A Intermolecular distances are less than molecular size.

B Kinetic energy of gas particles decreases with decreasing temperature.

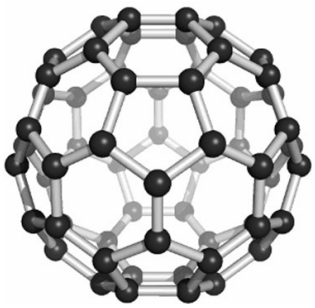
C Molecules move randomly and interact with one another.

D There are strong intermolecular forces between gas molecules.

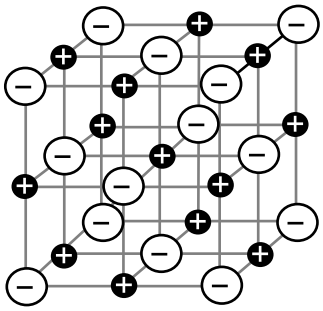
6 The diagram shows structures of three solids **X**, **Y** and **Z**.



X



Y



Z

Which row is correct for all three solids?

	solid **X**	solid **Y**	solid **Z**
A	low melting point	carbon sheets from layers	good electrolyte
B	delocalized electrons	giant molecular structure	made up of oppositely charged ions
C	lattice structure	held by strong London forces	allotrope of carbon
D	heat conductor	non-metallic	held together by metallic bond

7 Magnesium chloride is an ionic compound.
Which row shows equations of how magnesium chloride is formed from magnesium and chlorine?

	change in magnesium	change in chlorine
A	$Mg^{2+} + 2e^- \rightarrow Mg$	$Cl_2 + 2e^- \rightarrow 2Cl^-$
B	$Mg + 2e^- \rightarrow Mg^{2+}$	$2Cl \rightarrow 2Cl^- + 2e^-$
C	$Mg \rightarrow Mg^{2+} + 2e^-$	$Cl_2 + 2e^- \rightarrow 2Cl^-$
D	$Mg \rightarrow Mg^{+} + e^-$	$Cl + e^- \rightarrow Cl^-$

8 Which molecule has the smallest bond angles?

A BF_3

B CH_4

C CO_2

D NH_3

9 Which statement about NH_4^+ is correct?

A All of the hydrogen atoms are bonded to the nitrogen atom by dative covalent bonds.

B It has one lone pair of electrons.

C It combines with metals to form ammonium salts.

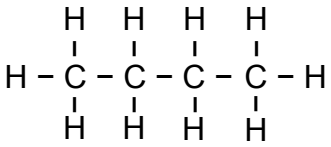
D It is a cation constituent of ammonium fertilisers.

10 Which of the rows show elements increasing in their first ionisation energy?

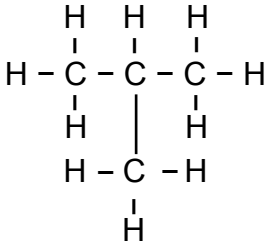
	lowest ionisation energy	→	highest ionisation energy
A	Ba	Ca	Be
B	C*l*	A*l*	Na
C	Br	I	At
D	A*l*	Na	C*l*

11 The structures of two isomers of C_4H_{10} are shown.

butane



2-methylpropane



Which type of forces can best explain why the boiling point of butane is higher than that of 2-methylpropane?

A dative covalent bond

B induced dipole forces

C hydrogen bonds

D permanent dipole forces

12 When hydrogen is burned in oxygen, water is formed.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O\ (l) \qquad \Delta H = -572\ kJ\ mol^{-1}$$

Which row is correct?

	value of $\Delta H_f^{\ominus}$ (H_2O) /kJ mol^{-1}	energy change
A	- 286	exothermic
B	- 286	endothermic
C	- 572	exothermic
D	- 572	endothermic

13 Which equation represents the standard enthalpy change of atomisation of chlorine?

A $Cl_2(g) \rightarrow 2Cl(g)$

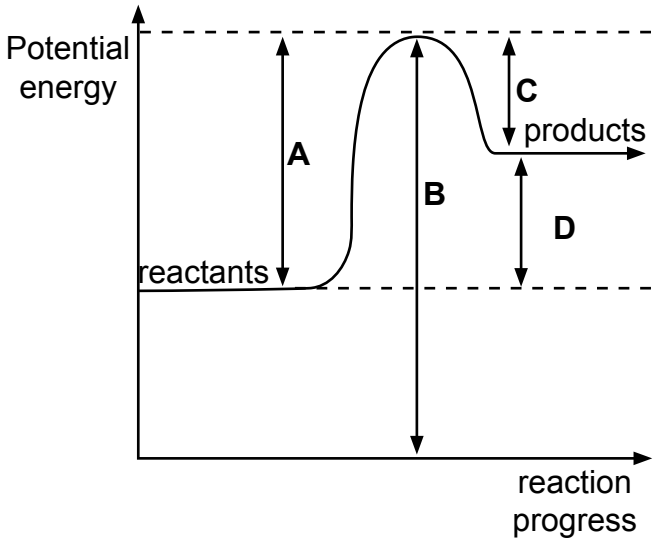
B $Cl(g) + Cl(g) \rightarrow Cl_2(g)$

C $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$

D $Cl(g) \rightarrow \frac{1}{2}Cl_2(g)$

14 The diagram shows a reaction pathway.

Which arrow represents the activation energy?



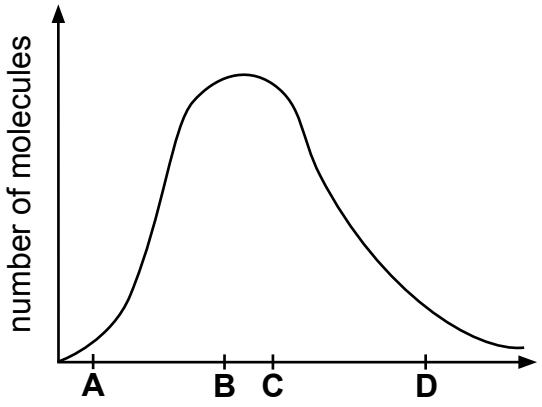
15 Copper reacts with concentrated nitric acid at room temperature.

$$Cu + \mathbf{y}HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

When the equation is balanced, what is the value of **y** and the state of NO_2?

	value of **y**	state of NO_2
A	2	(g)
B	6	(s)
C	4	(g)
D	3	(aq)

16 The diagram shows the Boltzmann energy distribution curve for a sample of gas.



Which letter represents the activation energy for the slowest decomposition of the gas at any given temperature?

17 Which statement is correct about an equilibrium?

A It occurs in a closed system.

B It occurs in combustion reactions only.

C The concentration of the forward reaction is greater than the backward reaction.

D Mass of reactants is always equal to mass of products.

18 Nitrogen gas reacts with chlorine gas in a reversible reaction to form nitrogen trichloride gas.
In an experiment, the concentrations of the species at equilibrium are;

$[N_2] = 0.20$ mol dm^{-3}, $[Cl_2] = 0.25$ mol dm^{-3} and $[NCl_3] = 0.50$ mol dm^{-3}.

What is the value of K_c, the equilibrium constant, under these conditions?

A 0.013

B 10

C 25

D 80

19 During a redox reaction, potassium manganate(VII) solution reacts with acidified hydrogen peroxide solution. A colour change is observed.

Which reaction causes the observed colour change?

A $H_2O_2 \rightarrow O_2 + 2H^+(aq) + 2e^-$

B $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

C $MnO(aq)_4^- + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

D $KMnO_4(s) + H_2O(l) \rightarrow K^+(aq) + MnO_4^-(aq) + H_2O_2(aq)$

20 Notations of four different species are shown.

$^{23}_{11}X^{+}$ $^{24}_{12}X^{2+}$ $^{24}_{11}X$ $^{27}_{14}X$

a b c d

X is not necessarily the same element.

For which two species is X the same element?

A a and c

B a and b

C b and d

D b and c

21 Which gas closely shows ideal gas behaviour at room temperature?

A ammonia

B helium

C hydrogen

D carbon dioxide

22 Which element is the most electronegative?

A hydrogen

B carbon

C fluorine

D oxygen

23 What is the pH of 0.010 mol dm^{-3} solution of hydrochloric acid?

A 1.0

B 1.5

C 2.0

D 2.5

24 Which substance is used as the leaching agent when manganese ore is refined?

A HC*l*

B H_2SO_4

C $MnSO_4$

D MnO_2

25 When solid ammonium sulfate is heated with excess sodium hydroxide solution, a reaction occurs.

$(NH_4)_2SO_4(s) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2NH_3(g)$

Which species are conjugate acid-base pairs in this reaction?

	conjugate acid-base pair I	conjugate acid-base pair II
A	$(NH_4)_2SO_4$ and Na_2SO_4	NaOH and NH_3
B	SO_4^{2-} and NH_4^+	Na^+ and OH^-
C	NH_4^+ and H_2O	NH_3 and OH^-
D	NH_4^+ and NH_3	H_2O and OH^-

26 Which chloride solution has no effect on litmus?

A Aluminium chloride

B Magnesium chloride

C Silicon tetrachloride

D Sodium chloride

27 Which metal sulfate is the least soluble in water?

A Barium

B Beryllium

C Calcium

D Magnesium

28 Calcium carbonate, $CaCO_3$, is used in agriculture.

What makes it suitable for this purpose?

A It is soluble in water.

B It is used to make fertilisers.

C It undergoes thermal decomposition.

D It increases the pH of the soil.

29 Which row shows the correct information about the Haber process?

	major source of hydrogen	conditions for production of ammonia
A	air	high pressure, high temperature
B	air	low temperature, catalyst
C	methane	high temperature, catalyst
D	methane	low pressure, high temperature

30 Potassium chlorate(V) is a strong oxidising agent used to make safety matches and disinfectants.

Which is the formula of this compound?

A K_5ClO

B K_5ClO_3

C $KClO$

D $KClO_3$

31 Which row shows the oxidation numbers of nitrogen in the given nitrogen compounds?

	N_2O	NO_3^-	NH_3
A	+1	+5	-3
B	-1	+1	+3
C	0	+5	+3
D	0	-1	-3

32 Which statement explains why iron forms more than one type of ion?

A It rusts easily when exposed to air and water.

B Its valence electrons are in both d and s orbitals.

C Its d orbitals are completely filled up.

D It forms coloured compounds.

33 Sulfur dioxide is an atmospheric pollutant.

Which information is correct about sulfur dioxide formation and its effect on polluting the atmosphere?

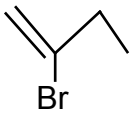
	formation	effects of pollution
A	burning of fossil fuels	greenhouse effect
B	car exhausts	brain damage
C	roasting metal sulfide ores	breathing difficulties
D	unburned hydrocarbons	acid rain

34 But-1-ene, C_4H_8 reacts with hydrogen bromide, HBr, to produce two products X and Y. Product Y is produced in a greater amount than product X.

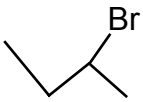
What is the skeletal formula of product Y?

A

B



C



D

35 An ester, $CH_3CH_2CH_2CO_2CH_3$, is hydrolysed by dilute sulfuric acid.

What is the empirical formula of the organic acid formed?

A CH_4O

B C_2H_4O

C CH_2O

D $C_3H_6O_2$

36 Which compound is formed when bromoethane reacts with ammonia?

A ethylammonium bromide

B ethanenitrile

C methylammonium bromide

D propanenitrile

37 An organic compound has the formula $(CH_3)_2CH(CH_2)_2OH$.

What is the name of the compound?

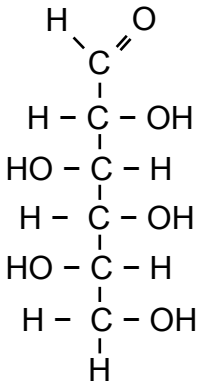
A pentan-1-ol

B 3-methylbutan-1-ol

C 1-methylbutan-4-ol

D 1-methylbutan-1-ol

38 The displayed formular of a simple sugar is shown.



How many chiral carbons does the molecule have?

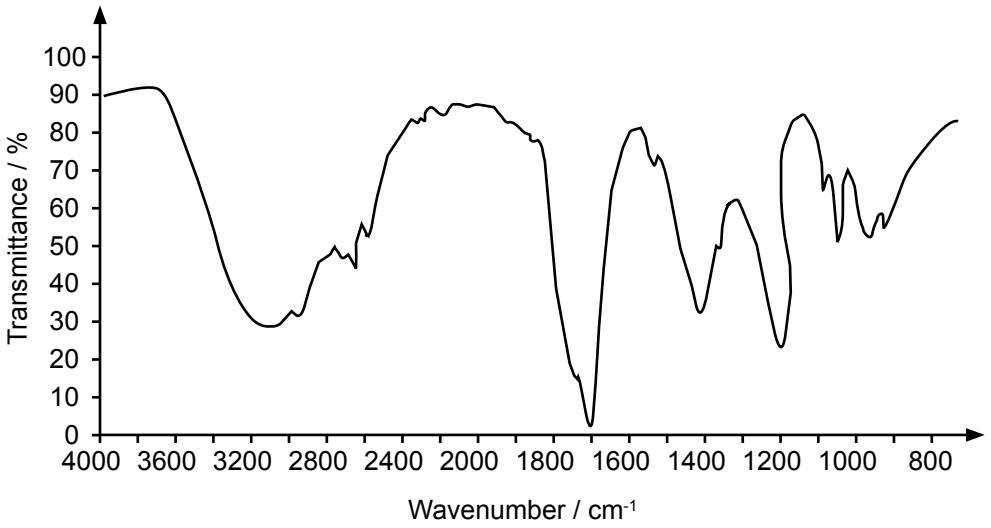
A 2

B 4

C 5

D 6

39 The diagram shows an infra-red spectrum of an organic compound.



Which compound is shown?

A ethanoic acid

B ethanol

C propanol

D propanone

40 Which reaction is an example of a nucleophilic substitution?

A $C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$

B $C_{10}H_{22} \rightarrow C_7H_{16} + C_3H_6$

C $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

D $C_2H_5Br + NaOH \rightarrow C_2H_5OH + NaBr$

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DATA

BOOKLET

1 Important values, constants and standards

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

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
Al	13	577	1820	2740	11 600
Si	14	786	1580	3230	4360
P	15	1060	1900	2920	4960
S	16	1000	2260	3390	4540
Cl	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		*Heteronuclear*	
Bond	**Energy (kJ mol^{-1})**	**Bond**	**Energy (kJ mol^{-1})**
C−C	350	C−H	410
C=C	610	C−C*l*	340
C≡C	840	C−Br	280
benzene	520	C−I	240
N−N	160	C−N	305
N=N	410	C=N	610
O−O	150	C≡N	890
Si−Si	222	C−O	360
P−P	200	C=O	740
S−S	264	C=O in CO_2	805
		N−H	390
		N−C*l*	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	C*l*$^-$	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	Ni^{3+} 0.056
	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, ketones and aldehydes carboxylic acids esters	1640–1690 1670–1740 1680–1730 1710–1750	***s*** ***s*** ***s*** ***s***
C-H	alkanes, CH_3 alkenes	2850–2950 3000–3100	***s*** ***w***
N-H	amides, amines	3300–3500	***w***
O-H	carboxylic acids, RCO_2-H H-bonded alcohol, RO-H free alcohol, RO-H	2500–3000 3200–3600 3580–3650	***s*** and very broad ***s*** ***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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