Chapter 1: The atom

Practice exercises

1.1 3.74 g Ti

1.3 20.18 u

Review questions

1.1 An atom is a chemical species comprising a central positively charged nucleus surrounded by one or more negatively charged electrons.

A covalent bond is a chemical bond which involves the sharing of electrons between neighbouring atoms.

An ion is a charged chemical species; the charge may be either positive or negative.

A cation is a positively charged chemical species.

An anion is a negatively charged chemical species.

An element is a chemical species comprised of only a single type of atom.

A compound is a chemical species comprised of two or more elements in a definite and unchanging proportion.

A reactant is a chemical species which is transformed in a chemical reaction.

A chemical reaction is a process whereby one or more chemical species is/are transformed into different chemical species. This generally involves the making and/or breaking of chemical bonds.

A product is the species formed in a chemical reaction.

1.3 The law of conservation of mass says that mass is conserved in chemical reactions. This being the case, then there must be the same mass on either side of the arrow in a chemical equation, and hence the same number of each type of atom on either side of the arrow.

1.5 The ratio of small whole numbers, mentioned in the law of multiple proportions, is consistent with the existence of discrete entities that combine with each other in integer multiples. These discrete entities are atoms.

1.7 They passed through undeflected because most of the atom is empty space and they did not encounter any particles that could deflect them. The force that did lead to some deflections was electrostatic; both the atomic nucleus and alpha particles are positively charged, and will repel each other.

1.9 Electrons are much lighter (about 10 000 times) than both protons and neutrons. Therefore, their contribution to the overall mass of an atom can be neglected for all but the most precise of measurements.

1.11 Isotopes are atoms of an element having identical numbers of protons (and therefore the same atomic numbers) but differing numbers of neutrons (and therefore different mass numbers). Their chemical behaviour is similar because the chemistry of an atom is determined primarily by its atomic number. For example, the isotopes protium, deuterium and tritium all undergo reactions typical of hydrogen, despite the fact they have different mass numbers.

1.13 (a) $^{107}_{47}Ag$

(b) $^{181}_{73}Ta$

(c) $^{162}_{66}Dy$

(d) $^{14}_{8}O$

1.15 (a) lithium
(b) gold
(c) uranium
(d) arsenic
(e) cobalt
(f) bromine
(g) platinum
(h) boron
(i) neon
(j) beryllium

1.17 False.

1.19 The atomic number — the number of protons in the nucleus (and the number of electrons in the neutral atom) — is related to the chemistry of an element. The periodic table is based on atomic numbers. The mass numbers, which vary with the number of neutrons in the atom, do not affect the chemistry of the elements as much as the number of protons.

1.21 Palladium and platinum are in the same group of the periodic table as nickel (group 10), so they might well be expected to occur together in nature because of their similar chemical properties and tendencies to form similar compounds.

1.23 There is simply no space in the periodic table for another element having an atomic number less than 92. All the elements from atomic number 1 (hydrogen) to atomic number 92 (uranium) have been discovered and accounted for. The only new elements that will be discovered are those with high atomic numbers. At present, the elements up to an atomic number of 118 are known. Any new elements will have atomic numbers greater than this.

1.25 ductility

1.27 oxygen (O_2), nitrogen (N_2), fluorine (F_2), chlorine (Cl_2)

1.29 Lv

1.31 Orbital.

1.33 Atoms in excited states can emit excess energy as light (photons).

Review problems

1.35 (c)

1.37 98.5 g chlorine.

1.39 64.0 g of carbon tetrachloride.

1.41 2.664 g oxygen.

1.43 $1.992\ 648\ 2 \times 10^{-23}$ g for one ^{12}C atom

1.45 14.01 u

1.47 2.0158 u

1.49 121.8 u

1.51
(a) 52 neutrons, 38 protons, 38 electrons
(b) 33 neutrons, 27 protons, 27 electrons
(c) 15 neutrons, 15 protons, 15 electrons
(d) 16 neutrons, 14 protons, 14 electrons

1.53
(a) Any three of the following elements: He, C, N, O, F, Ne, P, S, Cl, Ar, Se, Br, Kr, I, Xe, At, Rn.
(b) Any three of the following elements: Be, Mg, Ca, Sr, Ba, Ra.
(c) Any three of the following elements: La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu.
(d) Any three of the following elements: O, S, Se, Te, Po.

Additional exercises

1.55 X = 207.8 u
Y = 35.5 u.
XY_4 is $PbCl_4$.

1.57 $\dfrac{2 \text{ atoms As}}{5 \text{ atoms O}}$

1.59 Nucleus: $V \approx 5 \times 10^{-46}$ m^3
Atom: $V \approx 5 \times 10^{-31}$ m^3
There is a factor of 10^{15} difference between the volume occupied by the nucleus and the total volume of the atom.

1.61 (a) 10 electrons
(b) 17 electrons
(c) 32 electrons
(d) 10 electrons
(e) 50 electrons
(f) 50 electrons