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Chapter 27 Atomic Structure

1. The Greeks used philosophy in their investigation of scientific problems. They developed ideas by reasoning and discussion. Experimentation did not occur generally.

Modern scientists use the scientific method to investigate scientific problems. This involves, among other things, making a hypothesis and testing it.

2. (a) $E = \frac{V}{d} = \frac{210\ V}{0.026\ m}$

$\approx 8100\ Vm^{-1}$

(b) $Eq = mg$

$\therefore q = \frac{mg}{E} = \frac{1.05 \times 10^{-15} kg \times 9.8 ms^{-2}}{\frac{210}{0.026} JC^{-1} m^{-1}}$

$= 1.27 \times 10^{-18} C$ ← use original numbers to improve accuracy of ans (b)

(c) Charge on 1 electron $= 1.6 \times 10^{-19} C$

$\therefore$ No. of e's $= \frac{\text{Total charge}}{\text{charge on 1 } e^-} = \frac{1.27 \times 10^{-18}}{1.6 \times 10^{-19}}$

$= 8$

3. The study of science is our attempt to explain the natural events in the universe. The study of radioactivity is real science.

4. The discovery of X-rays led to the discovery of radioactivity. Without the discovery of X-rays, radioactivity would have been discovered, but at a later date.

5. The Curies used the electrometer (invented by Jacques and Pierre Curie) to study radioactivity (See Fig. 27.9 P604)

6. Alpha particles are helium ions: $^{2}_{2}He^{+2}$ They become neutral helium atoms by obtaining two electrons, from the filament IF in a CR tube.

Not a good Q.

7. Roentgen's experiments with cathode ray tubes led to the discovery of X-rays. The study of X-rays led to the discovery of radioactivity.

8. The alpha particle is large and relatively slow moving. It is slowed and eventually stopped by collisions with other particles. Its double positive charge and its large size ionizes other particles by shaking them apart (producing +ve and -ve ions) or by capturing electrons (producing +ve ions)

Gamma radiation are electromagnetic radiation and, having no charge, experience no electrical attraction or deflection. They have high penetration because they are only absorbed by a collision with a nucleus or electron.

9. Gold $^{197}_{79}Au$ has a large number number of protons in its nucleus. This would have a greater effect on any helium nucleus (alpha particle) in the vicinity.

Rutherford's experiments showed that the mass of the atom was concentrated in a tiny, positively charged nucleus. Most of the atom was space.

10. Not the right answer but still a good summary

Type of Radiation	Makeup	Penetrating Ability	Ionizing Ability
alpha α	2 protons 2 neutrons (a He nucleus)	absorbed by paper	a strong ionizing agent
beta β	an electron	can be absorbed by a few mm of metal foil	lower than for α radiation
gamma γ	very short wavelength electro-magnetic radiation	penetrates 1 meter of concrete	only weakly ionizing

11. In Thompson's model, the atom is a ball of positive charge, with electrons scattered throughout, like a plum pudding. If this model was correct, the alpha particles in Rutherford's experiment would not have scattered as much, since Thompson's atom is neutral (the alpha particles have a charge of +2).

12. $^{12}_{6}C$ $^{14}_{6}C$

13.

	atomic mass	no. of protons	no. of neutrons	no. of e's in neutral atom
$^{3}_{2}He$	3	2	1	2
$^{4}_{2}He$	4	2	2	2

14. Neutrons have high penetrating ability because they have no charge and do not interact with electrostatic fields around atoms. Being rather heavy particles, the carry considerable kinetic energy. In Joliot-Curie experiment, protons were physically knocked out of wax by neutrons.

15. (a) p = 1, n = 1 (b) p = 6, n = 6 (c) p = 8, n = 9 (d) p = 11, n = 12 (e) p = 16, n = 16 (f) p = 47, n = 60 (g) p = 53, n = 74 (h) p = 92, n = 146

16. In 100 atoms we have

92.22 weighing 28	=	2582.16
4.70 weighing 29	=	136.3
3.08 weighing 30	=	92.4
Total	=	2810.86
Average	=	28.1086

17(a) ^3_1H has 1 proton, 2 neutrons and 1 electron:

mass of 1 proton = 1·007 276 u
mass of 2 neutrons = 1·008 665 × 2
mass of 1 electron = 0·000 549
Total = 3·025 155
observed mass = 3·016 049
Mass defect = 0·009 106 u
∴ Binding energy = 0·009 106 × 931 MeV
(i) ≈ 8·47 MeV

(b) ^3_2He has 2 protons, 1 neutron and 2 electrons:

mass of 2 protons = 1·007 276 × 2 u
mass of 1 neutron = 1·008 665
mass of 2 electrons = 0·000 549 × 2
Total = 3·024 315
Observed mass = 3·016 030
Mass defect = 0·008285 u
∴ Binding energy = 0·008 285 × 931 MeV
(i) ≈ 7·713 MeV

(a)(ii) E per nucleon = $\frac{8\cdot47}{3}$ 2·82 MeV

(b)(ii) E per nucleon = $\frac{7\cdot713}{3} \approx 2\cdot571$ MeV

Questions (c) and (d) are repetative: not done

18 (a) $E = \frac{V}{d} = \frac{110\ V}{0\cdot02\ m}$

$= 5500\ V m^{-1}$

(b) $Eq = mg$

$\therefore q = \frac{mg}{E} = \frac{1\cdot077\times10^{-15} \times 9\cdot8\ m\ s^{-2}}{5500\ V\ m^{-1}\ (1V = 1JC^{-1})}$

$= 1\cdot92\times10^{-18}\ C \Rightarrow \frac{1\cdot92\times10^{-18}}{1\cdot6\times10^{-19}} = 12\ \bar{e}$'s

19 (a) 82 protons; 207 − 82 = 125 neutrons
(b) 17 protons; 35 − 17 = 18 neutrons
(c) 7 protons; 15 − 7 = 8 neutrons
(d) 85 protons; 215 − 85 = 130 neutrons
(e) 83 protons; 216 − 83 = 133 neutrons

20(a) nucleon is the collective name for protons and neutrons
neutron: dense, uncharged nucleon
nucleus: central, massive part of atom
nuclide: the name given to one combination of protons and neutrons. Isotope is the collective name while a nuclide is a particular atomic species eg there are 3 nuclides for hydrogen: ^2_1H; ^3_1H; ^1_1H

(b) No. **Neutron** is from the Greek meaning neither positive nor negative. **Nucleus** is from the Latin nucleus, a kernel.

21 $^{40}_{20}Ca$ has 20 neutrons and 40 nucleons
$^{42}_{20}Ca$ has 22 neutrons and 42 nucleons
$^{43}_{20}Ca$ has 23 neutrons and 43 nucleons
$^{45}_{20}Ca$ has 25 neutrons and 45 nucleons

22. (i) The atom $^{35}_{16}S$ has 16 protons and electrons and 19 neutrons:

mass of 16 protons = 1·007 276 × 16
mass of 16 electrons = 0·000 549 × 16
mass of 19 neutrons = 1·008 665 × 19
Total = 35·289 835 u
observed mass = 34·969 033
mass defect = 0·320 802
∴ binding energy/nucleon = $\frac{0\cdot320\ 802 \times 931\ MeV}{35}$
= 8·53 MeV/nucleon

22.(ii) $^{235}_{92}U$ has 92 protons and electrons and 143 neutrons

mass of 92 protons = 1·007 276 × 92
mass of 92 electrons = 0·000 549 × 92
mass of 143 neutrons = 1·008 665 × 143
Total = 236·958995
observed mass = 235·04394
mass defect = 1·915055 u
binding en/nucleon = $\frac{1\cdot915055 \times 931}{235}$
= 7·59 MeV/nucleon

22(iii) and 22(iv): do as above. Q23 leave out

24(a)(i) The filament is heated to give electrons enough energy to escape the metal
(ii) The electrons accelerate because they are repelled by the −ve cathode and attracted by the +ve anode.

(b)(i) This will make the filament hotter, giving more e⁻'s escape energy ∴ greater no. of e⁻'s flowing
(ii) This will have no effect on the number of e⁻'s flowing but it will increase the energy of each

25. $E = \frac{V}{d} = \frac{1200\ V}{0\cdot024\ m}$

$q = 3 \times 1\cdot6\times10^{-19}\ C$

$Eq = mg$

$\therefore m = \frac{Eq}{g} = \frac{1200\times1\cdot6\times10^{-19}\times3}{0\cdot024\times9\cdot8}$

$= 2\cdot45\times10^{-15}\ kg$

26. $Eq = mg$

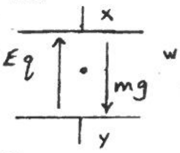
$\therefore q = \frac{mg}{E}$ (= total charge on sphere)

∴ no. of e⁻'s = $\frac{q}{\text{charge on } 1e^-} = \frac{3\cdot52\times10^{-14}\times9\cdot8}{9\cdot8\times10^4\times1\cdot6\times10^{-19}}$

= 22 electrons

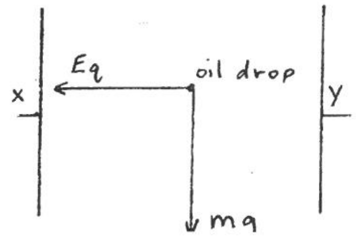
27. Alpha particles with a charge of +2 would be strongly affected by repulsive forces of a heavy nucleus (= many protons). As the alpha got closer to the nucleus, the force of repulsion would increase greatly since $F \propto \frac{1}{d^2}$ (ie halve the distance, × 4 the force)
For the above reasons A, B and E are incorrect. C is incorrect, for although it correctly shows the closer particle repelled the most, the outer particle seems totally unaffected.
D is the best alternative but I do not like the question because it appears the alpha particle goes PAST the nucleus before it is strongly repelled.

28.

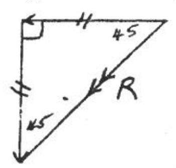


① when stationary: $mg = Eq$

② when turned on the side:



③ vector diag:



∴ R is in the direction of F in Fig. 27.24