UNIT 10

RADIOACTIVITY AND NUCLEAR CHEMISTRY

Answers

Lesson 1 – What is radioactivity?

Summary Activity 1.1: What is a nucleus made of?

- number of protons, sum of number of protons and number of neutrons, atoms with the same atomic number but different mass numbers
- proton has mass 1 and charge 1; neutron has mass 1 and charge 0; electron has mass 0 and charge -1
- particle in the nucleus (ie proton or neutron)
- $^{18}_{8}\mathrm{O}$
- 26 protons, 30 neutrons
- Forming ions from atoms, usually by taking away electrons

Test your knowledge 1.2: Describing radiation and radioactivity

(a) two protons and two neutrons; atomic number decreases by 2 and mass number decreases by 4
(b) an electron emitted from the nucleus; atomic number increases by 1
(c) emission of alpha and beta particles reduce potential energy of nucleus; excess energy is emitted as a gamma ray
(d) (i) $^{228}_{90}\mathrm{Th} \rightarrow {}^{224}_{88}\mathrm{Ra} + {}^{4}_{2}\alpha$; (ii) $^{19}_{8}\mathrm{O} \rightarrow {}^{19}_{9}\mathrm{F} + {}^{0}_{-1}\beta$

Lesson 2 – What are the main features of radiation and radioactivity?

Test your knowledge 2.1: Describing the properties and dangers of radiation

(a) Alpha is the most ionising – it is large and has a +2 charge; gamma is the least ionising – it has no charge
(b) Gamma is the most penetrating as it has no mass so does not collide with particles; it has no charge so is not strongly ionising; alpha is the least penetrating because it is strongly ionising and is destroyed when it ionises another particle
(c) It can kill/burn cells or cause them to mutate and become cancerous
(d) Their penetrating power means that they cannot be stopped by skin, containers or walls
(e) If they get inside the body through inhalation, ingestion or injection

Test your knowledge 2.2: Using half-lives

(a) The time taken for the amount or activity of a sample to fall to half of its original value
(b) 7.2 mins = 3 half-lives so 87.5% decayed
(c) 121 mins = 2 half-lives so half-life = 60.5 mins
(d) 12.5% of value = 3 half-lives = 24 days

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Lesson 3 - How can radioactivity and nuclear reactions be useful?

Test your knowledge 3.1: Understanding nuclear fission and nuclear fusion

(a) Breaking up of a nucleus into two or more smaller nuclei; $^{235}_{92}\mathrm{U} \rightarrow {}^{139}_{56}\mathrm{Ba} + {}^{94}_{36}\mathrm{Kr} + 2{}^{1}_{0}\mathrm{n}$
(b) Joining of two or more nuclei to make a single nucleus; $^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$
(c) Heat released when nucleus breaks up; this boils water which drives a turbine which drives a generator
(d) Very high temperature needed to start the reaction
(e) Atom bomb – energy released as a result of nuclear fission; hydrogen bomb - most energy released as a result of nuclear fusion

Lesson 4 – How is radioactivity used in medicine, agriculture and industry?

Test your knowledge 4.1: Using radioactivity

(a) 6.25% is four half-lives, so fossil is 5730 x 4 = 22920 years old
(b) Monitoring how fast plants take up certain nutrients; identifying blockages and leaks in underground pipes; locating blockages in digestive or circulatory system
(c) They are directed at the cancer externally using lots of different angles; cancer cells are more easily killed by radiation than healthy cells

4.2 END-OF-UNIT QUIZ
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1. They have no mass or charge so do not interact with other materials; as a result it is very difficult to protect oneself against them
2. (i) $^{210}_{83}\mathrm{Bi} \rightarrow {}^{206}_{81}\mathrm{Tl} + {}^{4}_{2}\alpha$; (ii) $^{24}_{11}\mathrm{Na} \rightarrow {}^{24}_{12}\mathrm{Mg} + {}^{0}_{-1}\beta$
3. 12.5% is three half-lives so age = 5730 x 3 = 17190 years
4. $^{235}_{92}\mathrm{U} \rightarrow {}^{144}_{55}\mathrm{Cs} + {}^{90}_{37}\mathrm{Rb} + {}^{1}_{0}\mathrm{n}$ (1 neutron released)
5. From nuclear fusion; the sun fuses hydrogen into helium; eg $^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$
6. Detection: use iodine-131 as a tracer; it is absorbed by thyroid cancers, when absorbed the gamma radiation it emits can be detected, making it possible to identify and locate a tumour; if injected into the tumour it can release alpha radiation into the tumour which will help kill it