

# 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)
- $^{18}_8\text{O}$
- 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)  $^{228}_{90}\text{Th} \rightarrow ^{224}_{88}\text{Ra} + \frac{4}{2}\alpha$ ; (ii)  $^{19}_8\text{O} \rightarrow ^{19}_9\text{F} + ^0_{-1}\beta$

#### 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

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### 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

### 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;  ${}_{92}^{235}\text{U} \rightarrow {}_{56}^{139}\text{Ba} + {}_{36}^{94}\text{Kr} + 2{}_{0}^1\text{n}$
- (b) Joining of two or more nuclei to make a single nucleus;  ${}_{1}^2\text{H} + {}_{1}^2\text{H} \rightarrow {}_{2}^3\text{He} + {}_{0}^1\text{n}$
- (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  $5730 \times 4 = 22920$  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)  ${}_{83}^{210}\text{Bi} \rightarrow {}_{81}^{206}\text{Tl} + {}_{2}^4\alpha$ ; (ii)  ${}_{11}^{24}\text{Na} \rightarrow {}_{12}^{24}\text{Mg} + {}_{-1}^0\beta$
3. 12.5% is three half-lives so age =  $5730 \times 3 = 17190$  years
4.  ${}_{92}^{235}\text{U} \rightarrow {}_{55}^{144}\text{Cs} + {}_{37}^{90}\text{Rb} + {}_{0}^1\text{n}$  (1 neutron released)
5. From nuclear fusion; the sun fuses hydrogen into helium; eg  ${}_{1}^2\text{H} + {}_{1}^3\text{H} \rightarrow {}_{2}^4\text{He} + {}_{0}^1\text{n}$
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