CHEM 9.2.5 NUCLEAR CHEMISTRY

Nuclear chemistry provides a range of materials

5.1 Distinguish between **stable and radioactive isotopes** and describe the **conditions** under which a **nucleus is unstable**

- **Isotopes**: elements w/ different no. of neutrons.

$$^{A}_{Z}X$$

A = MASS NUMBER = p + n
Z = ATOMIC NO. = p

- **Radioactive isotopes** release **radiation** (spontaneous emission) due to **unstable nuclei**
- **Stable neutron ratio** begins 1.0, 50 = 1.3, 80 = 1.5, > 83 all nuclei are not stable

Type	Formula	Charge	Rel. Mass	Penetration
alpha (α)	$^{4}_{2}\mathrm{He}$	+2	4	Low – paper
beta (β)	$^{0}_{-1}e$	-1	1/2000	Medium – 0.5 mm Al, 0.6 mm Pb
gamma (γ)	-	0	0	High – 5 cm Pb, 15 cm concrete

  - Gamma rays are emitted with alpha/beta emissions
  - Neutrons decompose into a proton and an electron, so:

$$^{60}_{27}Co \rightarrow {}^{0}_{-1}e + {}^{234}_{90}Th$$

5.2 Describe how **transuranic elements** are **produced**

- **Transuranic element**: element with **atomic number > 92** (uranium)
- Do not exist **in nature** – made in **nuclear reactors** and **particle accelerators**
- Made when isotope is **not fissionable/fissile** (able to be split)
- Uranium 238 bombarded w/ neutron → Uranium 239 (unstable) → Neptunium and beta decay (n → p + e)

$$^{238}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow \underset{\text{(unstable)}}{^{239}_{92}\mathrm{U}} \rightarrow {}^{0}_{-1}\mathrm{e} + {}^{239}_{93}\mathrm{Np}$$

5.3 Describe how **commercial radioisotopes** are **produced**

NUCLEAR REACTOR – structure which controlled nuclear fission occurs

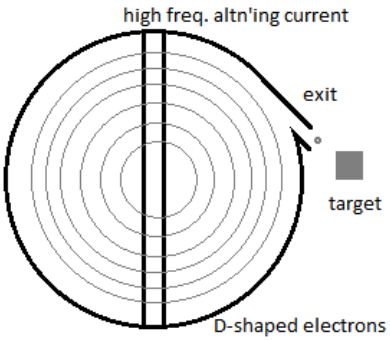
- **Nuclear fission**: neutrons bombard atoms + split into 2 approx. equal fragments
- Uranium 235 splits into Ba and Kr

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3(^{1}_{0}n) + energy$$

  - Energy **> than combustion** of coal/petrol per gram
- Extra **neutrons absorbed by rods** to prevent hitting more U atoms (otherwise atomic bomb)
- Used for **electricity** (Japan and USA), used in Australia for **medical + industrial** use

PARTICLE ACCELERATOR – used for bombarding heavy nuclei w/ high speed +'ve particles

- Two types, linear accelerator and cyclotrons
    - **Linear Accelerator** – straight line with alternating + and – tubes
        - > 1 km length
    - **Cyclotron** – accelerates particle in a spiral (compact)
        - Strong magnetic field and high frequency alternating current



5.4 Identify **instruments and processes** that can be used to **detect radiation**

- **Photographic film** – first detected (Becqerel)
    - Darkens, used w/ **radiation badges**
- **Cloud Chamber** – supersaturated water/alcohol vapour
    - Radiation ionises (lose an e^-) the air + causes liquid to form
    - α: straight dense tracks, β: zigzag, γ: faint
- **Geiger Müller counter** – contains a gas (**argon**)
    - Radiation ionises gas and moves to the middle to **create electric pulse** - counts
    - Argon then moves to –'ve casing to complete circuit
- **Scintillation counter** – exposed to radiation = **flash of light**, collected and amplified

5.5 Identify one use of a **named radioisotope** in **industry** and in **medicine**

- **Cobalt-60** used in industrial radiography to inspect metal parts + welds for defects
- **Technetium 99m** used to detect circulation disorders in the body, e.g. blood clots

5.6 Describe the way in which the above named **industrial and medical radioisotopes** are **used** and explain their use in **terms of their properties**

COBALT 60

- Used by **directing radiation** towards object w/ film on other side
    - **More radiation** passes through cracks or flaws = **structural problems** detected
- Emits **gamma rays** – can penetrate metal parts
- **½ life of 4 to 6 years** + can be used **chemically inert** – long life equipment

TECHNETIUM 99M

- m = **unstable**, loses the m when stable
- **Attaches** to an appropriate substance and emits **gamma radiation**
    - **Radiation** picked up to detect **clotting/damage** after **heart attacks**
- Emits **low energy gamma radiation** – low damage to tissues, but can be measured w/ scintillation counter
- Very short **½ life of 6 hours** – quickly eliminated from body