UNIT 6 – RADIOACTIVITY AND NUCLEAR CHEMISTRY

When is it happening?	Wednesday May 20th
How long will it take?	30 minutes
What is the format?	multiple choice questions (5 points) short answer questions (20 points)
What is it worth?	15% of your Q4 grade
What will it cover?	See below
What resources will be useful?	Unit 6 Lesson Helpsheets, Research Task 6.1 Class Worksheets 6.1 – 6.4

Americium-241 **WRITING ATOMIC SYMBOLS** $^{241}_{95}\mathrm{Am}$

atomic number (Z) = number of protons (eg atomic number of Be = 4)

mass number (A) = number of protons (Z) + number of neutrons

isotopes = atoms with the same number of protons but different numbers of neutrons

Atomic symbols are written like this: $^{A}_{Z}\mathrm{E}$ (A = mass number, Z = atomic number)

Eg $^{13}_{6}\mathrm{C}$ has 6 protons (hence it is C) and a mass number of 13 (so it has 7 neutrons)

Names of isotopes are written **Element-A** (eg carbon-13)

$^{4}_{2}\mathrm{He}$ **TYPES OF RADIATION** $^{0}_{-1}\mathrm{e}$

- Some nuclei have too many protons or too many neutrons – these are unstable
  Unstable atoms emit particles from their nucleus to become more stable: alpha or beta particles
  Atoms which do this are said to be **radioactive**

- Alpha particles contain two protons and two neutrons – symbol $^{4}_{2}\mathrm{He}$ **or** $^{4}_{2}\alpha$
  After atoms emit alpha particles the mass decreases by 4 and the atomic number decreases by 2:
  eg $^{232}_{90}\mathrm{Th} \rightarrow {}^{228}_{88}\mathrm{Ra} + {}^{4}_{2}\alpha$ (thorium-232 emits an alpha particle and becomes radium-228)

- Beta particles are high energy electrons – symbol $^{0}_{-1}\mathrm{e}$ **or** $^{0}_{-1}\beta$
  They are emitted when a neutron in the nucleus turns into a proton
  After atoms emit beta particles the mass stays the same and the atomic number increases by 1:
  eg $^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{28}\mathrm{Ni} + {}^{0}_{-1}\beta$ (cobalt-60 emits an beta particle and becomes nickel-60)

- Gamma (γ) rays are excess energy often emitted alongside alpha and beta particles

Properties of radiation			
Type of radiation	Α	β	γ
penetrating power	low - stopped by 4 cm of air	medium – stopped by a thin sheet of metal	high – almost impossible to stop
Ionising power	high – it destroys everything it touches	Medium	low – you won't notice it in small amounts

HALF LIVES

- the rate at which atoms emit alpha or beta radiation varies from atom to atom varies greatly
- It depends on how much of the substance is present
- The time taken for half of a sample to decay is constant for each isotope and is called the **half-life**
- Total time = half-life x number of half-lives

Number of half-lives completed	% of sample remaining
0	100
1	50
2	25
3	12.5
4	6.25

Example 1: if the half-life of a sample is 2 days, what % of a sample will remain after 8 days?

Answer 1: Number of half-lives = 8/2 = 4
4 half-lives = **6.25% left**

Example 2: In a sample of 400 radioactive atoms, only 50 are left after six hours. What is the half-life of the sample?

Answer 2: 50/400 * 100 = 12.5% = 3 half-lives
This took 6 hours, so one half-live = 6/3 = 2 hours

Example 3: carbon-14 has a half-life of 5700 years. The carbon-14 content of a skeleton was found to contain 25% of the amount in living bone. How long ago did the skeleton die?

Answer 3: 25% = 2 half-lives
Total time = 2 x 5700 = 11400 years

NUCLEAR FISSION AND NUCLEAR FUSION

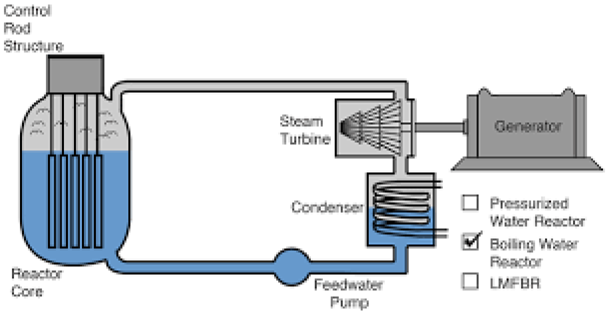
- the atom with the most stable nucleus is $^{56}_{26}\mathrm{Fe}$
- atoms smaller than $^{56}_{26}\mathrm{Fe}$ can become more stable by joining together to make larger atoms; this is called **nuclear fusion**: eg $^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n}$
  nuclear fusion needs high temperatures and pressures and can only happen in the sun
  nuclear fusion reactions release a lot of energy
- atoms much larger than $^{56}_{26}\mathrm{Fe}$ can become more stable by splitting up into smaller atoms; this is called **nuclear fission**: eg $^{235}_{92}\mathrm{U} \rightarrow ^{90}_{38}\mathrm{Sr} + ^{143}_{54}\mathrm{Kr} + 2^{1}_{0}\mathrm{n}$
  this can only happen when atoms are bombarded with neutrons; fission reactions also release neutrons which can lead to a chain reaction

BALANCING NUCLEAR EQUATIONS

The sum of the masses and the sum of the charges must be the same on both sides of the equation:
$^{235}_{92}\mathrm{U} \rightarrow ^{90}_{38}\mathrm{Sr} + ^{143}_{54}\mathrm{Kr} + 2^{1}_{0}\mathrm{n}$
(mass on LHS = 235, mass on RHS = 90 + 143 + 2 = 235; charge on LHS = 92; charge on RHS = 54 + 38 = 92)

Example: Complete the following equation: $^{2}_{1}\mathrm{H} + ^{3}_{2}\mathrm{He} \rightarrow ^{4}_{2}\mathrm{He} + X$
Answer: on LHS = 2 + 3 = 5; mass on RHS = 4 so mass missing = 1
Charge on LHS = 1 + 2 = 3; charge on RHS = 2 so charge missing = 1 so X = $^{1}_{1}\mathrm{H}$

NUCLEAR POWER
Nuclear fission and fusion reactions release a lot of energy



Controlled fission reaction = nuclear power
- boron rods absorb extra neutrons and stop an explosion
- nuclear power stations can produce a lot of energy and emit almost no CO_2
- but there are cost/safety concerns
- and fission reactions produce harmful radioactive products

Uncontrolled fission/fusion reaction = nuclear bomb
(no control rods)