INKPHYSICS FLASHCARDS

Nuclear physics

Year 13 · 47 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the AQA data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/physics/flashcards.

RECALL

State the absorber that stops beta radiation.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

DEFINITION

Define: Inverse-square law for gamma.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

Explain how to correct a count rate for background.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

State how lead absorbs gamma radiation.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

State the most ionising radiation.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

State the composition, mass and charge of each radiation.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

SPOT THE ERROR

Say what is wrong with this claim:

An atom is a tiny solid ball, packed with matter all the way through.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

DEFINITION

Define: Half-life.

RADIOACTIVE DECAY AND HALF-LIFE

DEFINITION

The intensity of gamma radiation from a point source is $I = k/x^2$, so doubling the distance quarters the intensity.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

A few millimetres of aluminium stop beta particles, which pass through paper.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

By attenuation, each further thickness cutting the intensity by the same fraction, so thick lead reduces gamma to a safe level rather than halting it at a fixed range.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

Subtract the background count rate, measured with the source absent, from every reading before analysis.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

Alpha: two protons and two neutrons, 4u, +2e. Beta-minus: an electron, about u/1840, -1e. Beta-plus: a positron, about u/1840, +1e. Gamma: a photon, no mass and no charge.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

RECALL

Alpha: the most strongly ionising and least penetrating, stopped by paper or a few centimetres of air.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

DEFINITION

The time taken for the number of undecayed nuclei in a sample, and so its activity, to halve.

RADIOACTIVE DECAY AND HALF-LIFE

SPOT THE ERROR

An atom is mostly empty space, not solid: most alpha particles passed straight through the foil, and nearly all the mass and all the positive charge sit in a tiny nucleus.

RUTHERFORD SCATTERING AND THE NUCLEAR ATOM

DEFINITION

Define: Activity.

RADIOACTIVE DECAY AND HALF-LIFE

DEFINITION

Define: Decay constant.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

Explain the random nature of radioactive decay.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

State the half-life from the decay constant.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

State the gradient of a ln N against t decay graph.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

Explain the half-life trade-off for a medical tracer.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

State the experimental evidence that radioactive decay is random.

RADIOACTIVE DECAY AND HALF-LIFE

EQUATION · NOT ON THE AQA DATA SHEET

Activity falling with time:

A = ?

RADIOACTIVE DECAY AND HALF-LIFE

DEFINITION

The probability per unit time that a given nucleus decays: λ, in s^{-1}.

RADIOACTIVE DECAY AND HALF-LIFE

DEFINITION

The number of nuclei in a sample decaying per second: $A = \lambda N$, in becquerels.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

$T_{½} = \ln 2/\lambda$.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

Each nucleus has a constant probability of decay per unit time, unaffected by physical or chemical conditions.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

Long enough to image before the activity fades, short enough that the dose clears from the patient quickly.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

A straight line of gradient $-\lambda$; the straightness is evidence the decay is exponential.

RADIOACTIVE DECAY AND HALF-LIFE

EQUATION · NOT ON THE AQA DATA SHEET

$\mathbf{A = A_0 e^{-\lambda t}}$

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

Counts recorded over successive equal intervals from an unchanging source do not repeat: they scatter about a mean. Those fluctuations in count rate are the evidence, because a regular process would return the same count every interval. The scatter is about $\sqrt{N}$ for a count of N, so long counts have a smaller fractional error.

RADIOACTIVE DECAY AND HALF-LIFE

SPOT THE ERROR

Say what is wrong with this claim:

After two half-lives, a sample has all gone.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

State the constant in the nuclear radius equation.

NUCLEAR RADIUS AND DENSITY

RECALL

State the closest-approach energy condition.

NUCLEAR RADIUS AND DENSITY

RECALL

Explain why electrons are used to measure nuclear radii.

NUCLEAR RADIUS AND DENSITY

RECALL

State the electron diffraction feature that fixes the nuclear radius.

NUCLEAR RADIUS AND DENSITY

EQUATION · NOT ON THE AQA DATA SHEET

Closest approach: the alpha's kinetic energy:

$\mathbf{E_k = ?}$

NUCLEAR RADIUS AND DENSITY

EQUATION · NOT ON THE AQA DATA SHEET

Nuclear density from R_0:

$\boldsymbol{\rho = ?}$

NUCLEAR RADIUS AND DENSITY

SPOT THE ERROR

Say what is wrong with this claim:

Bigger nuclei are packed tighter, so heavy elements have denser nuclei.

NUCLEAR RADIUS AND DENSITY

RECALL

About 1.2 fm, the gradient of the straight-line graph of R against $A^{1/3}$.

NUCLEAR RADIUS AND DENSITY

SPOT THE ERROR

Each half-life halves what remains rather than removing it all: after two half-lives a quarter of the nuclei are still undecayed, and the sample never quite reaches zero.

RADIOACTIVE DECAY AND HALF-LIFE

RECALL

They do not experience the strong force, and their de Broglie wavelength can be made comparable to the nuclear diameter.

NUCLEAR RADIUS AND DENSITY

RECALL

At closest approach, all the alpha particle's kinetic energy has become electrostatic potential energy.

NUCLEAR RADIUS AND DENSITY

EQUATION · NOT ON THE AQA DATA SHEET

$$E_k = (Qq)/(4\pi\varepsilon_0 r_{min})$$

NUCLEAR RADIUS AND DENSITY

RECALL

The angle of the first minimum of the intensity against angle graph.

NUCLEAR RADIUS AND DENSITY

SPOT THE ERROR

Nuclear density is the same for all nuclei: $R = R_0A^{1/3}$ makes volume proportional to nucleon number, so every nucleus has a density of about 2×10^{17} kg m^{-3}.

NUCLEAR RADIUS AND DENSITY

EQUATION · NOT ON THE AQA DATA SHEET

$$\rho = (3u)/(4\pi R_0^3)$$

NUCLEAR RADIUS AND DENSITY

DEFINITION

Define: Binding energy.

MASS-ENERGY AND BINDING ENERGY

RECALL

State how to find binding energy from mass defect.

MASS-ENERGY AND BINDING ENERGY

DEFINITION

Define: Mass defect.

MASS-ENERGY AND BINDING ENERGY

RECALL

State the energy equivalent of 1 u.

MASS-ENERGY AND BINDING ENERGY

DEFINITION

Define: Atomic mass unit.

MASS-ENERGY AND BINDING ENERGY

RECALL

State where the binding energy per nucleon curve peaks.

MASS-ENERGY AND BINDING ENERGY

RECALL

State the quantity used to compare nuclear stability.

MASS-ENERGY AND BINDING ENERGY

SPOT THE ERROR

Say what is wrong with this claim:

Mass is always conserved.

MASS-ENERGY AND BINDING ENERGY

RECALL

A nucleus's binding energy equals its mass defect multiplied by c^2: $\Delta E = \Delta mc^2$.

MASS-ENERGY AND BINDING ENERGY

DEFINITION

The energy needed to separate a nucleus into its constituent nucleons.

MASS-ENERGY AND BINDING ENERGY

RECALL

1 u is equivalent to 931.5 MeV.

MASS-ENERGY AND BINDING ENERGY

DEFINITION

The difference between the mass of a nucleus and the total mass of its separate nucleons.

MASS-ENERGY AND BINDING ENERGY

RECALL

Iron-56, at about 8.8 MeV per nucleon: among the most tightly bound of all nuclei. The true maximum is a broad iron-nickel shelf, nickel-62 fractionally the highest, but iron-56 is the answer expected.

MASS-ENERGY AND BINDING ENERGY

DEFINITION

One twelfth of the mass of a carbon-12 atom, 1.661×10^{-27} kg.

MASS-ENERGY AND BINDING ENERGY

SPOT THE ERROR

Mass alone is not conserved; total mass-energy is. A nucleus has less mass than its separated nucleons, the difference having been released as binding energy via $E = mc^2$.

MASS-ENERGY AND BINDING ENERGY

RECALL

Binding energy per nucleon, never total binding energy.

MASS-ENERGY AND BINDING ENERGY

DEFINITION

Define: Critical mass.

FISSION AND FUSION

DEFINITION

Define: Induced fission.

FISSION AND FUSION

RECALL

State the products of induced fission.

FISSION AND FUSION

RECALL

State the energy released per fission of uranium-235.

FISSION AND FUSION

RECALL

Explain why fusion needs very high temperatures.

FISSION AND FUSION

RECALL

State how to find reaction energy from nuclear masses.

FISSION AND FUSION

SPOT THE ERROR

Say what is wrong with this claim:

Splitting any atom releases energy.

FISSION AND FUSION

DEFINITION

Define: Moderator.

NUCLEAR REACTORS AND SAFETY

DEFINITION

A heavy nucleus splitting into two smaller nuclei after absorbing a neutron.

FISSION AND FUSION

DEFINITION

The minimum mass of fissile material in which, on average, one neutron per fission goes on to cause another fission.

FISSION AND FUSION

RECALL

About 200 MeV per fission.

FISSION AND FUSION

RECALL

Each fission releases energy and two or three further neutrons.

FISSION AND FUSION

RECALL

Total mass before minus total mass after, in u, multiplied by 931.5 gives the energy released in MeV.

FISSION AND FUSION

RECALL

The positive nuclei must have enough kinetic energy to approach closely against their electrostatic repulsion. Even in a star they fall short of the barrier, and quantum tunnelling closes the remaining gap.

FISSION AND FUSION

DEFINITION

The reactor material that slows fission neutrons to thermal speeds by elastic collisions.

NUCLEAR REACTORS AND SAFETY

SPOT THE ERROR

Fission only releases energy for nuclei heavier than iron, the most tightly bound nucleus. Splitting lighter nuclei would absorb energy; for them fusion is the energy-releasing process.

FISSION AND FUSION

DEFINITION

Define: Thermal neutron.

NUCLEAR REACTORS AND SAFETY

DEFINITION

Define: Control rods.

NUCLEAR REACTORS AND SAFETY

DEFINITION

Define: Coolant.

NUCLEAR REACTORS AND SAFETY

RECALL

Explain the emergency shut-down of a reactor.

NUCLEAR REACTORS AND SAFETY

RECALL

State the first stage of spent fuel storage.

NUCLEAR REACTORS AND SAFETY

EQUATION · NOT ON THE AQA DATA SHEET

Neutron energy kept in an elastic moderator collision:

fraction kept = ?

NUCLEAR REACTORS AND SAFETY

SPOT THE ERROR

Say what is wrong with this claim:

A nuclear reactor can explode like a nuclear bomb.

NUCLEAR REACTORS AND SAFETY

DEFINITION

Rods of boron or cadmium that absorb neutrons to control the rate of the chain reaction.

NUCLEAR REACTORS AND SAFETY

DEFINITION

A fission neutron slowed to the speeds at which it is most likely to be absorbed and cause further fission.

NUCLEAR REACTORS AND SAFETY

RECALL

The control rods drop fully into the core, absorbing enough neutrons to stop the chain reaction.

NUCLEAR REACTORS AND SAFETY

DEFINITION

The fluid, such as water or carbon dioxide, that transfers thermal energy from the core to raise steam for the turbines.

NUCLEAR REACTORS AND SAFETY

EQUATION · NOT ON THE AQA DATA SHEET

fraction kept = $((M - m)/(M + m))^2$

NUCLEAR REACTORS AND SAFETY

RECALL

Cooling ponds, where water shields the radiation and carries away decay heat while short-lived isotopes decay.

NUCLEAR REACTORS AND SAFETY

SPOT THE ERROR

A reactor cannot explode like a bomb: its low-enriched fuel and control rods keep exactly one neutron per fission causing another fission; the worst failure is a meltdown, not a nuclear explosion.

NUCLEAR REACTORS AND SAFETY