INKPHYSICS FLASHCARDS

Particles

Year 12 · 52 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.

DEFINITION

Define: Isotopes.

CONSTITUENTS OF THE ATOM

DEFINITION

Define: Specific charge.

CONSTITUENTS OF THE ATOM

DEFINITION

Define: Nucleon number A.

CONSTITUENTS OF THE ATOM

DEFINITION

Define: Proton number Z.

CONSTITUENTS OF THE ATOM

RECALL

State the relative mass of the electron.

CONSTITUENTS OF THE ATOM

RECALL

State the specific charge of the neutron.

CONSTITUENTS OF THE ATOM

EQUATION · NOT ON THE AQA DATA SHEET

Specific charge:

specific charge = ?

CONSTITUENTS OF THE ATOM

SPOT THE ERROR

Say what is wrong with this claim:

Atoms of the same element are identical.

CONSTITUENTS OF THE ATOM

DEFINITION

The charge of a particle divided by its mass: Q/m, in $C\ kg^{-1}$.

CONSTITUENTS OF THE ATOM

DEFINITION

Atoms with the same number of protons but different numbers of neutrons: the same element with a different nucleon number.

CONSTITUENTS OF THE ATOM

DEFINITION

The number of protons in a nucleus, which determines the element.

CONSTITUENTS OF THE ATOM

DEFINITION

The total number of protons and neutrons in a nucleus.

CONSTITUENTS OF THE ATOM

RECALL

Zero, because the neutron has mass but no charge.

CONSTITUENTS OF THE ATOM

RECALL

About 1/1800 of the mass of a proton.

CONSTITUENTS OF THE ATOM

SPOT THE ERROR

Atoms of one element share a proton number but not necessarily a neutron number: isotopes of the same element have different nucleon numbers and masses.

CONSTITUENTS OF THE ATOM

EQUATION · NOT ON THE AQA DATA SHEET

specific charge = (Q)/(m)

CONSTITUENTS OF THE ATOM

RECALL

State the range of the strong nuclear force.

STABLE AND UNSTABLE NUCLEI

RECALL

State the effect of alpha decay on A and Z.

STABLE AND UNSTABLE NUCLEI

RECALL

State the effect of beta-minus decay on A and Z.

STABLE AND UNSTABLE NUCLEI

RECALL

State the evidence that led to the neutrino hypothesis.

STABLE AND UNSTABLE NUCLEI

SPOT THE ERROR

Say what is wrong with this claim:

Positive charges can never stick together.

STABLE AND UNSTABLE NUCLEI

DEFINITION

Define: Annihilation.

ANTIMATTER AND PHOTONS

RECALL

Explain why annihilation gives two photons.

ANTIMATTER AND PHOTONS

DEFINITION

Define: Pair production.

ANTIMATTER AND PHOTONS

RECALL

A decreases by 4 and Z decreases by 2.

STABLE AND UNSTABLE NUCLEI

RECALL

Attractive between nucleons out to about 3 fm, repulsive below about 0.5 fm.

STABLE AND UNSTABLE NUCLEI

RECALL

Beta particles are emitted with a continuous range of energies up to a maximum, so an unseen particle must carry the remainder.

STABLE AND UNSTABLE NUCLEI

RECALL

A is unchanged and Z increases by 1.

STABLE AND UNSTABLE NUCLEI

DEFINITION

A particle and its antiparticle meet and their mass is converted to energy. For a pair annihilating at rest this is released as two photons back to back.

ANTIMATTER AND PHOTONS

SPOT THE ERROR

Protons do repel electrically, but within about 3 fm the strong nuclear force is attractive and overpowers that repulsion, holding the nucleons of a nucleus together.

STABLE AND UNSTABLE NUCLEI

DEFINITION

A single high-energy photon passing close to a nucleus converts into a particle and its antiparticle.

ANTIMATTER AND PHOTONS

RECALL

A single photon could not conserve momentum. For a pair annihilating at rest, two photons travelling in opposite directions conserve both momentum and energy.

ANTIMATTER AND PHOTONS

RECALL

State the role of the nucleus in pair production.

ANTIMATTER AND PHOTONS

RECALL

Explain how a particle and its antiparticle compare.

ANTIMATTER AND PHOTONS

RECALL

State the minimum photon energy for electron-positron pair production.

ANTIMATTER AND PHOTONS

RECALL

State what a mass of 1 MeV/c^2 means.

ANTIMATTER AND PHOTONS

RECALL

State how to convert a mass in MeV/c^2 into kilograms.

ANTIMATTER AND PHOTONS

SPOT THE ERROR

Say what is wrong with this claim:

Antimatter is science fiction.

ANTIMATTER AND PHOTONS

DEFINITION

Define: The weak interaction.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

State the exchange particles of the weak interaction.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

Same mass and rest energy, with charge, baryon number and lepton number all reversed. A neutral pair such as the neutron and antineutron shares the same zero charge.

ANTIMATTER AND PHOTONS

RECALL

Pair production usually happens near a nucleus, which recoils so that momentum is conserved.

ANTIMATTER AND PHOTONS

RECALL

The mass whose rest energy is 1 MeV. Rearranging $E = mc^2$ gives $m = E/c^2$, so an energy divided by c^2 is a mass and the number does not change: a rest energy of 0.511 MeV is a mass of 0.511 MeV/c^2. (Edexcel only.)

ANTIMATTER AND PHOTONS

RECALL

1.022 MeV, the total rest energy of the pair.

ANTIMATTER AND PHOTONS

SPOT THE ERROR

Antimatter is real and routinely produced: every particle has an antiparticle with the same mass and opposite values of charge and the other quantum numbers, a neutral particle's antiparticle being neutral too, and annihilation and pair production are observed in experiments.

ANTIMATTER AND PHOTONS

RECALL

Multiply by 1.60×10^{-13} to turn the MeV into joules, then divide by c^2. One MeV/c^2 is 1.78×10^{-30} kg. Reverse both steps to come back, so a mass in kilograms times c^2 and then divided by 1.60×10^{-19} is a rest energy in eV. (Edexcel only.)

ANTIMATTER AND PHOTONS

RECALL

The W^+ and W^- bosons.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

DEFINITION

The only interaction that can change quark flavour, as when a down quark becomes an up quark in beta-minus decay.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

State the four fundamental interactions.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

State the exchange particle of the electromagnetic interaction.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

State the neutrino emitted in beta-minus decay.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

Explain why the weak interaction has a very short range.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

SPOT THE ERROR

Say what is wrong with this claim:

When two things repel, nothing passes between them.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

DEFINITION

Define: Hadrons.

CLASSIFICATION OF PARTICLES

DEFINITION

Define: Baryon.

CLASSIFICATION OF PARTICLES

DEFINITION

Define: Meson.

CLASSIFICATION OF PARTICLES

RECALL

The virtual photon.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

Gravity, electromagnetic, weak nuclear and strong nuclear.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

Its exchange particles, the W bosons, are massive, so they exist only briefly and travel a tiny distance.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

RECALL

An electron antineutrino.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

DEFINITION

Particles that feel the strong interaction.

CLASSIFICATION OF PARTICLES

SPOT THE ERROR

Repulsion is carried, not conjured at a distance: the particles exchange a virtual boson (a photon for electromagnetic repulsion) which transfers the momentum that pushes them apart.

PARTICLE INTERACTIONS AND EXCHANGE PARTICLES

DEFINITION

A hadron made of a quark and an antiquark.

CLASSIFICATION OF PARTICLES

DEFINITION

A hadron made of three quarks, such as the proton or the neutron.

CLASSIFICATION OF PARTICLES

DEFINITION

Define: Leptons.

CLASSIFICATION OF PARTICLES

RECALL

State the members of the lepton family.

CLASSIFICATION OF PARTICLES

RECALL

State the only stable free baryon.

CLASSIFICATION OF PARTICLES

RECALL

State the exchange particle of the strong force between nucleons.

CLASSIFICATION OF PARTICLES

RECALL

Explain how strange particles are produced and decay.

CLASSIFICATION OF PARTICLES

SPOT THE ERROR

Say what is wrong with this claim:

Matter is just protons, neutrons and electrons.

CLASSIFICATION OF PARTICLES

RECALL

State the quark composition of the proton.

QUARKS AND ANTIQUARKS

RECALL

State the quark composition of the neutron.

QUARKS AND ANTIQUARKS

RECALL

The electron, the muon, their neutrinos and their antiparticles.

CLASSIFICATION OF PARTICLES

DEFINITION

Fundamental particles that do not feel the strong interaction.

CLASSIFICATION OF PARTICLES

RECALL

The pion.

CLASSIFICATION OF PARTICLES

RECALL

The proton; every other free baryon eventually decays into it. A neutron bound in a stable nucleus does not decay.

CLASSIFICATION OF PARTICLES

SPOT THE ERROR

Protons, neutrons and electrons are not the whole of matter: accelerators and cosmic rays produce many other particles, classified as hadrons, which feel the strong interaction, and leptons, which do not.

CLASSIFICATION OF PARTICLES

RECALL

Produced in pairs by the strong interaction; they decay by the weak interaction.

CLASSIFICATION OF PARTICLES

RECALL

Up, down, down (udd).

QUARKS AND ANTIQUARKS

RECALL

Up, up, down (uud).

QUARKS AND ANTIQUARKS

RECALL

State the six flavours of quark and their charges.

QUARKS AND ANTIQUARKS

RECALL

Explain neutron decay at quark level.

QUARKS AND ANTIQUARKS

RECALL

Explain kaon decay at quark level.

QUARKS AND ANTIQUARKS

SPOT THE ERROR

Say what is wrong with this claim:

Protons and neutrons are fundamental.

QUARKS AND ANTIQUARKS

RECALL

State the quantities conserved in every particle interaction.

CONSERVATION LAWS

RECALL

State the strangeness conservation rule.

CONSERVATION LAWS

RECALL

State the quark change in beta-plus decay.

CONSERVATION LAWS

RECALL

Explain why a free proton cannot decay.

CONSERVATION LAWS

RECALL

One down quark in udd becomes an up quark, giving uud, with a W^- boson emitted.

QUARKS AND ANTIQUARKS

RECALL

Up, down, strange, charm, top and bottom. Up, charm and top carry +2/3 e; down, strange and bottom carry -1/3 e; every antiquark carries the opposite charge. (CIE only: AQA, OCR and Edexcel examine u, d and s alone.)

QUARKS AND ANTIQUARKS

SPOT THE ERROR

Protons and neutrons are not fundamental: each is made of three quarks, uud for the proton and udd for the neutron, as shown by deep inelastic electron scattering.

QUARKS AND ANTIQUARKS

RECALL

A K^- is a strange quark with an anti-up. The strange quark becomes an up quark, emitting a W^-, and that W^- becomes a down quark with an anti-up, which is the π^-; the spectating anti-up pairs with the new up quark to make the π^0. Strangeness changes by one, so only the weak interaction can do it.

QUARKS AND ANTIQUARKS

RECALL

Conserved in strong interactions; can change by 0 or ±1 in weak interactions.

CONSERVATION LAWS

RECALL

Charge, baryon number, each lepton number, energy and momentum.

CONSERVATION LAWS

RECALL

It is the lightest baryon and baryon number is conserved, so there is no lighter baryon for it to become.

CONSERVATION LAWS

RECALL

An up quark becomes a down quark ($u \rightarrow d$).

CONSERVATION LAWS

RECALL

Explain why a neutral particle leaves no track in a detector.

CONSERVATION LAWS

RECALL

State what the curvature of a particle track tells you.

CONSERVATION LAWS

RECALL

Explain why a particle track spirals inwards.

CONSERVATION LAWS

SPOT THE ERROR

Say what is wrong with this claim:

In particle physics, anything can happen.

CONSERVATION LAWS

RECALL

Which way it curls gives the sign of the charge, because opposite charges bend opposite ways in the same field. How tightly it curls gives the momentum, through $r = p/(BQ)$, so a wide arc is a fast particle and a tight one a slow particle. (Edexcel only.)

CONSERVATION LAWS

RECALL

A track is the trail of ionisation a charged particle leaves in the medium it crosses, and a neutral particle ionises nothing. It is inferred instead from the gap between where it was made and where it decayed, which is why a decay of a neutral particle shows as a V with nothing leading into it. (Edexcel only.)

CONSERVATION LAWS

SPOT THE ERROR

Not every reaction is allowed: a particle interaction can only happen if charge, baryon number and each lepton number are conserved, and strangeness is also conserved in strong interactions.

CONSERVATION LAWS

RECALL

The particle ionises as it travels and so loses energy, its momentum falls, and by $r = p/(BQ)$ the radius falls with it turn by turn. The tight end is therefore the end reached last, which fixes the direction of travel and with it the sign of every charge in the picture. (Edexcel only.)

CONSERVATION LAWS