PEARSON EDEXCEL IGCSE PHYSICS · 4PH1

PHYSICS



EXAM QUESTION PACK

SECTION 7: RADIOACTIVITY AND PARTICLES (PACK 2)

SCORE	PERCENTAGE
/102	%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. Pearson Edexcel has not endorsed, approved or been involved in the production of it. Pearson Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson Edexcel publishes its past papers, mark schemes and examiner reports. Always check the current specification at qualifications.pearson.com before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

This is a question about alpha particles.

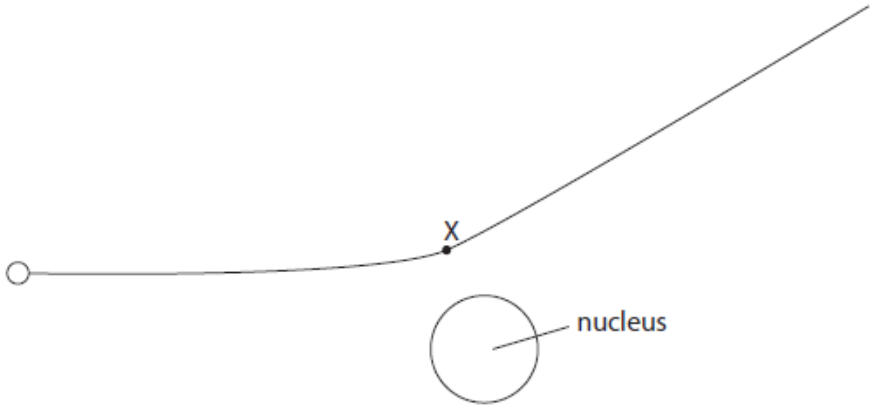
(a) Describe the nature of an alpha particle.

(1)

.....

.....

(b) The diagram shows the path of an alpha particle as it passes close to a nucleus.



(i) Draw an arrow from point X to show the force on the alpha particle due to the nucleus.

Label this force Y.

(2)

(ii) Draw an arrow to show the force on the nucleus due to the alpha particle.

Label this force Z.

(2)

(iii) Explain how the path of the alpha particle shows whether the nucleus is positive, negative or neutral.

(3)

.....

.....

.....

.....

.....

.....

(c) The alpha particle experiences a resultant force of 3.6 N and has a mass of 6.6×10^{-27} kg.

Calculate the acceleration of the alpha particle.

(3)

acceleration = ... m/s^2

(Total for question = 11 marks)

Q2.

This question is about astrophysics.

(a) (i) What is a star formed from?

(1)

☒ **A** a black dwarf

☒ **B** a nebula

☒ **C** a planet

☒ **D** a white dwarf

(ii) Which of these indicates that the Universe is expanding?

(1)

☒ **A** galaxies are moving further away from each other

☒ **B** galaxies rotate

☒ **C** it takes millions of light years for light to reach us from some stars

☒ **D** some stars in the Milky Way are accelerating towards our Sun

(iii) Which of these provides evidence for the Big Bang theory?

(1)

☒ **A** cosmic microwave background radiation

☒ **B** nebulae

☒ **C** neutron stars

☒ **D** ultrasound radiation

(iv) Which of these does red-shift provide evidence for?

(1)

☒ **A** galaxies are moving away from each other

☒ **B** nebulae contract to form stars

☒ **C** red giants shrink to red dwarfs

☒ **D** white dwarfs expand into red giants

(b) The spectra of stars and galaxies show lines at specific wavelengths that correspond to the spectra of hydrogen, helium and carbon.

Give reasons why lines corresponding to these elements are found in spectra from typical galaxies.

(2)

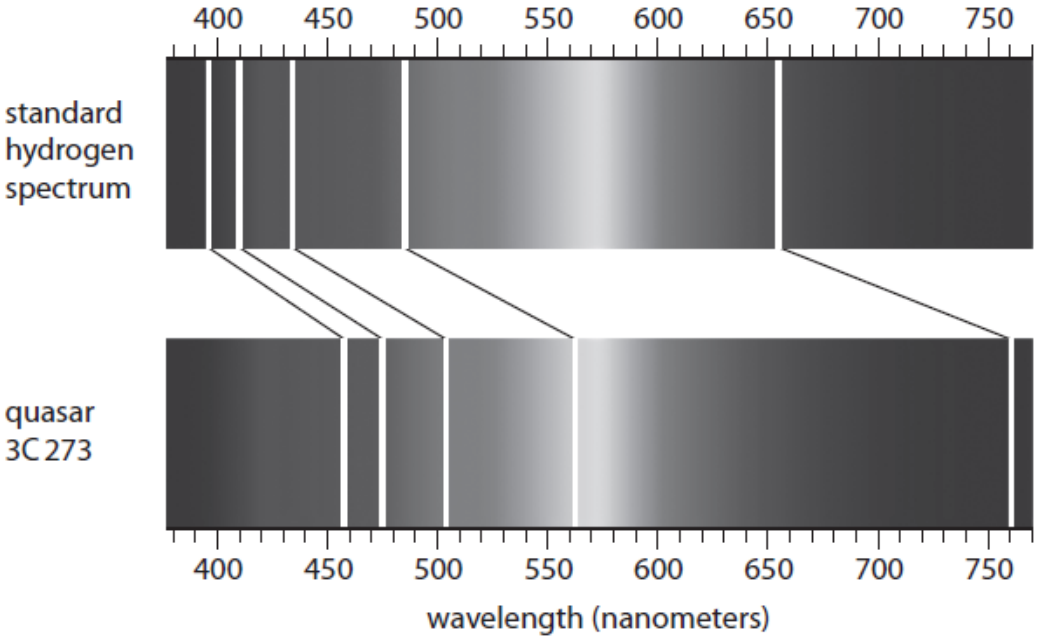
.....

.....

.....

.....

(c) The spectrum of light from an astronomical object called a quasar can be compared to the spectrum of hydrogen on Earth.



(i) Calculate the change in wavelength, $\Delta\lambda$, for the line at the red end of the spectrum.

(2)

$\Delta\lambda$ = ... nm

(ii) Calculate a value for the recessional velocity of the quasar using your value for $\Delta\lambda$.

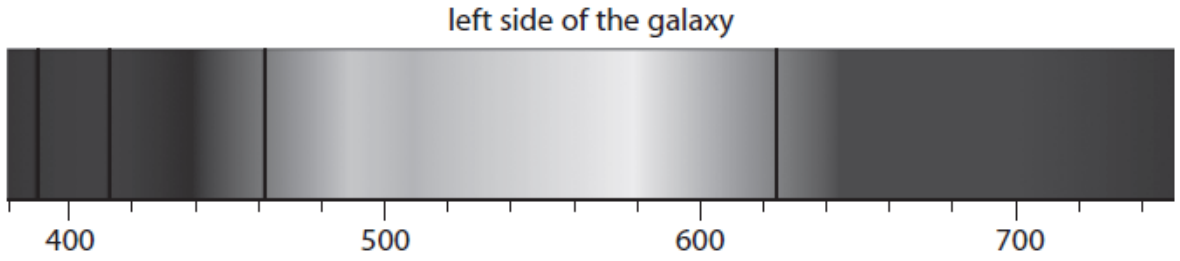
speed of light in free space, $c = 3.0 \times 10^5$ km/s

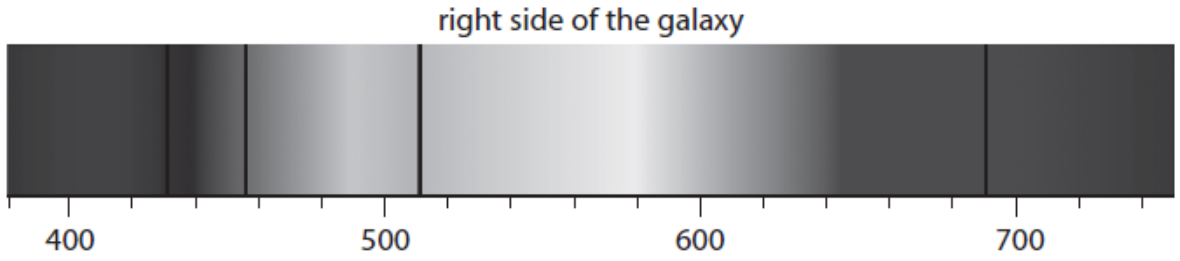
(3)

recessional velocity = ... km/s

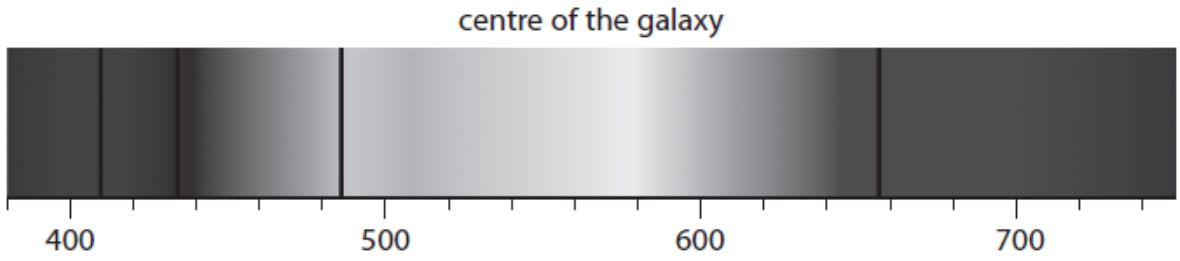
(d) An astronomer observes the light from a nearby galaxy.

She notices that the spectra for hydrogen from the right side and left side of the galaxy are different.





She compares them to the spectrum for hydrogen from the centre of the galaxy.



Explain what information the two spectra give about the movement of the galaxy.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 14 marks)

Q3.

An aircraft travels along a runway.

(a) The aircraft starts from rest and has a constant acceleration of 4.1 m/s^2.

Calculate the distance required to reach take-off speed of 75 m/s.

(3)

distance = ... m

(b) The aircraft takes off and reaches its maximum height above the ground.

At maximum height, the background radiation count rate is higher than on the ground.

(i) Explain what is meant by background radiation.

(2)

.....

.....

.....

.....

(ii) Suggest why there is a limit to the number of hours that an airline pilot can fly at maximum height.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 8 marks)

Q4.

Lightning strikes the Earth frequently and often starts in rain clouds.

Inside the clouds, powerful winds move ice particles and tiny water droplets.

The bottom of the clouds becomes negatively charged and the top becomes positively charged.

(a) Give a reason why the clouds become charged.

(1)

.....

.....

(b) The ground below the cloud becomes positively charged.

Explain why the ground becomes charged.

You should use ideas about electron movement in your answer.

(2)

.....

.....

.....

.....

(c) The build-up of charge in the cloud and in the ground causes the air to ionise.

This means that the air becomes a conductor, and a low resistance path from the cloud to the ground is formed.

(i) State what is meant by the term **ionise**.

(1)

.....

(ii) State the relationship between charge, current and time.

(1)

.....

(iii) During one lightning strike, the mean current is 32 kA and the mean charge transferred is 15 C.

Calculate the mean time duration of a lightning strike.

(2)

mean time = ... s

(iv) The mean energy transferred during the lightning strike is 510×10^6 J.

Show that the resistance of the air is approximately 1000 Ω.

(4)

(Total for question = 11 marks)

Q5.

A machine called the synchrocyclotron (SC) was designed to cause protons to move in a circular path using strong magnetic fields.

(a) The SC used electromagnets to produce the strong magnetic fields.

Describe the construction of a simple electromagnet.

You may draw a diagram to support your answer.

(3)

.....

.....

.....

.....

.....

.....

(b) The diagram shows a proton moving at velocity v in the magnetic field produced by the SC.



The direction of the magnetic field is into the page.

Using the left hand rule, determine the direction of the force acting on the proton due to the magnetic field.

(1)

.....

(c) The SC is surrounded by very thick concrete walls.

The radiation produced by the SC created atoms of radioactive barium-133 in the concrete walls.

Barium-133 has a half-life of 10.5 years.

(i) State what is meant by the term **half-life**.

(2)

.....

.....

.....

.....

(ii) In 1990, the SC stopped being used at CERN, a research centre.

In 1990, the largest number of barium-133 atoms were found 40 cm deep in the concrete walls.

Since 2014, members of the public have been allowed to visit the SC at CERN.

Explain why the radioactive barium-133 in the concrete walls is not a risk to people visiting the SC.

(2)

.....

.....

.....

.....

.....

.....

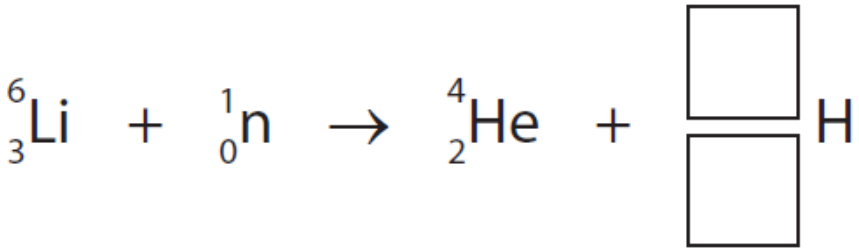
(Total for question = 8 marks)

Q6.

In extreme conditions, the isotope lithium-6 can be made to undergo nuclear fission.

(a) The lithium-6 nucleus absorbs a neutron and produces an alpha particle and an isotope of hydrogen.

The incomplete nuclear equation for this fission is



(i) Complete the nuclear equation by writing the numbers in the boxes.

(2)

(ii) Explain why this fission does not cause a chain reaction.

(2)

.....

.....

.....

.....

.....

.....

(b) Explain the difference between nuclear fission and nuclear fusion.

(2)

.....

.....

.....

.....

(Total for question = 6 marks)

Q7.

This question is about nuclear fusion.

(a) The incomplete nuclear equation shows the fusion of two isotopes of hydrogen.

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + X$$

(i) Identify particle X in the nuclear equation.

(1)

.....

(ii) Each fusion reaction releases approximately 3×10^{-12} J of energy.

Estimate how many reactions are needed to produce 1 J of energy.

Give your answer to 1 significant figure.

(2)

number of reactions = ...

(iii) Explain why this fusion reaction will only happen at high temperature and high pressure.

(3)

.....

.....

.....

.....

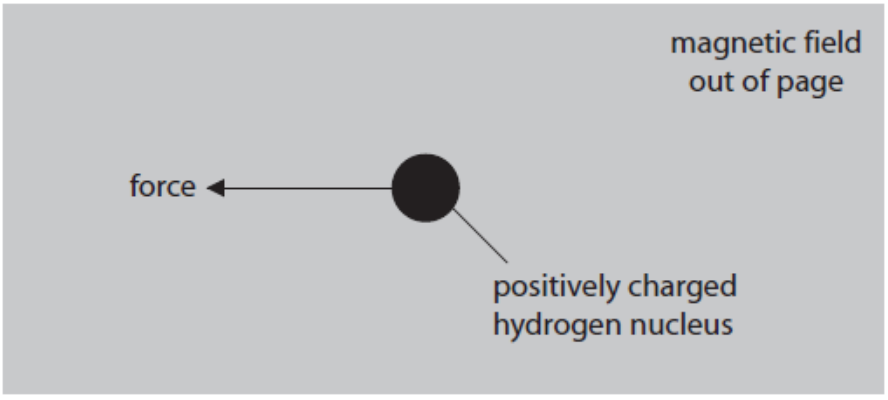
.....

.....

(b) A tokamak is an experimental nuclear fusion reactor.

Strong magnetic fields are used to contain the reactants inside the tokamak.

(i) The diagram shows a positively charged hydrogen nucleus in a uniform magnetic field directed out of the page.



The nucleus experiences a force acting to the left because of the magnetic field.

Deduce how the nucleus must behave to experience this force.

(2)

.....

.....

.....

.....

(ii) Suggest how engineers working on the tokamak could increase the force on the nucleus.

(1)

.....

.....

(Total for question = 9 marks)

Q8.

Nuclear fusion is a process that occurs in the core of stars.

(a) Which is the best description of nuclear fusion?

(1)

☒ **A** large nucleus splitting into two smaller nuclei

☒ **B** nucleus emitting an electromagnetic wave

☒ **C** nucleus releasing a beta particle

☒ **D** two smaller nuclei joining together to form a larger nucleus

(b) Two nuclei are close together and stationary.

Explain why these nuclei will move apart.

(2)

.....

.....

.....

.....

(c) Describe the conditions needed for fusion to occur in the core of a star.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q9.

This is a question about a nuclear fusion power station.

(a) Explain what happens during nuclear fusion.

(3)

.....

.....

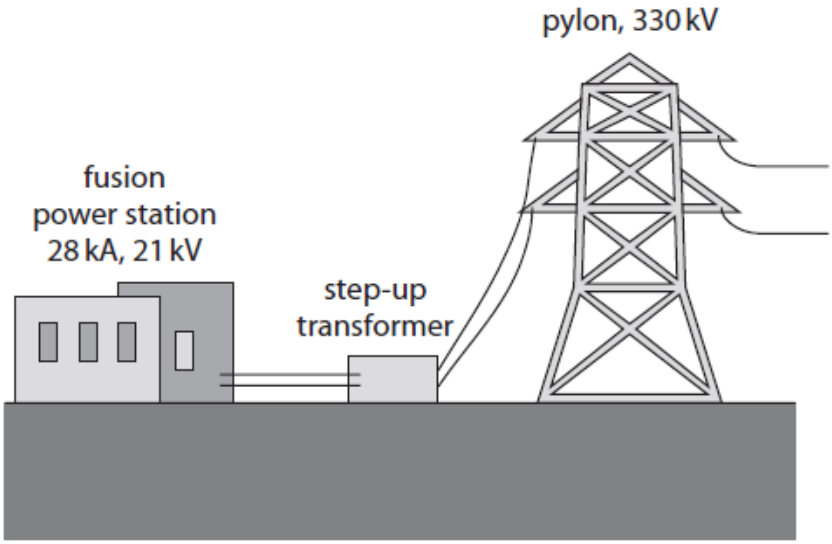
.....

.....

.....

.....

(b) The diagram shows how a fusion power station could supply the National Grid in the future.



(i) State the main method of energy transfer from the fusion power station generator to the primary coil of the
step-up transformer.

(1)

.....

(ii) The fusion power station could supply the input coil of the step-up transformer with a current of 28 kA at a
voltage of 21 kV.

The output coil of the transformer has a voltage of 330 kV.

Assume the transformer is 100% efficient.

Calculate the current in the output coil of the transformer.

(3)

current = ... kA

(Total for question = 7 marks)

Q10.

(a) The table gives some statements about different parts of a nuclear reactor.

Place ticks (✓) in the boxes to show which statements are about the moderator and which statements are about a control rod in a nuclear reactor.

(3)

	Moderator	Control rod
absorbs excess neutrons		
can be made of boron		
can be made of water or graphite		
is lowered into or raised from the reactor core to adjust the rate of reaction		
reduces the speed of neutrons so they are more likely to cause fission		

(b) Describe the role of shielding around a nuclear reactor.

(2)

.....

.....

.....

.....

(c) A uranium fuel rod is made from fuel pellets that contain uranium-235 and uranium-238.

Only uranium-235 undergoes nuclear fission in the reactor core.

Energy is released when the uranium-35 nuclei undergo fission.

The box gives some data about a typical uranium fuel pellet.

Total mass of uranium in fuel pellet	0.0088 kg
Percentage (by mass) of uranium-235 in fuel pellet	3.0 %
Mass of uranium-235 atom	3.90×10^{-25} kg
Total energy released from fuel pellet due to fission	2.17×10^{10} J

(i) Calculate the number of uranium-235 atoms in the fuel pellet.

(2)

number of uranium-235 atoms = ...

(ii) Calculate the energy released when the nucleus of a single atom of uranium-235 undergoes fission.

(2)

energy released = ... J

(Total for question = 9 marks)

Q11.

The nuclear equation shows how a nucleus of uranium-236 may undergo nuclear fission.

$$^{236}_{92}U \rightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + \boxed{}\,{}^{1}_{0}n$$

(a) Determine how many neutrons are released in this fission process.

(1)

number of neutrons = ...

(b) The table gives some of the constituents of this nuclear fission.

Complete the table by putting one tick (✓) in each row to show whether the constituent is a parent nucleus or a daughter nucleus.

(2)

Constituent	Parent nucleus	Daughter nucleus
strontium-94		
uranium-236		
xenon-140		

(c) Describe how the neutrons released in this fission process can cause a chain reaction.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q12.

The photograph shows a glass plate made from uranium glass.



© Laura Healey/Shutterstock

Uranium oxide is used to give the glass a green colour.

(a) Uranium-238 is the most common isotope of uranium and can be represented using this symbol.

$$^{238}_{92}U$$

(i) State what information the numbers 92 and 238 give about the nucleus of this isotope of uranium.

(2)

92.....

238.....

(ii) Uranium-238 decays by alpha emission.

Describe how the nucleus of a uranium-238 atom changes as a result of alpha emission.

(2)

.....

.....

.....

.....

(b) The table gives some information about the uranium glass plate.

mass of plate	1.1 kg
percentage (%) of plate made of uranium-238 (by mass)	4.5%
mass of uranium-238 atom	4.0×10^{-27} kg

(i) Calculate the number of uranium-238 atoms in the plate.

(2)

number of atoms = ...

(ii) Uranium-238 is an alpha emitter and has a half-life of 4.5 billion years.

Explain why it is safe to eat food from the uranium glass plate.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 9 marks)