Questions are for both separate science and combined science students unless indicated in the question

Q1.

A teacher measured the background radiation in a laboratory. **(Physics only)**

(a) Which sources of background radiation are natural and which are man-made? **(Physics only)**

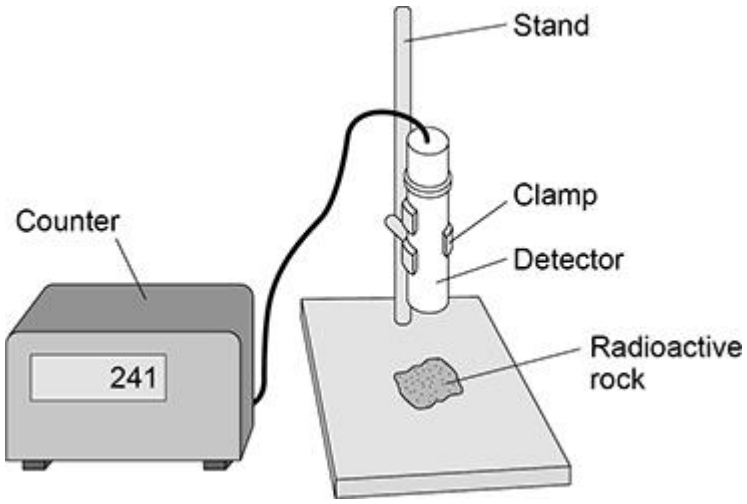
Tick (✓) **one** box in **each** row.

Source of background radiation	**Natural**	**Man-made**
Cosmic rays		
Medical X-rays		
Nuclear accidents		
Radon gas		

(2)

The teacher measured the radiation emitted by four different types of radioactive rock.

The figure below shows the equipment used.



Each radioactive rock was placed below the detector one at a time.

The radiation was recorded as the number of counts in 1 minute.

The experiment was repeated with different materials between each rock and the detector.

The table below shows the results.

	Number of counts in 1 minute		
	No material	One sheet of paper	Thick aluminium sheet
No rock	21	20	22
Rock **A**	450	448	18
Rock **B**	385	387	356
Rock **C**	870	21	20
Rock **D**	620	473	214

(b) Which radioactive rock emitted only alpha radiation? **(Physics only)**

Give a reason for your answer.

Tick (✓) **one** box.

Rock **A** ☐

Rock **B** ☐

Rock **C** ☐

Rock **D** ☐

Reason _____

_____

(2)

(c) Which radioactive rock emitted only beta radiation? **(Physics only)**

Give a reason for your answer.

Tick (✓) **one** box.

Rock **A** ☐

Rock **B** ☐

Rock **C** ☐

Rock **D** ☐

Reason _____

_____

(2)

(d) The teacher took safety precautions during the experiment.

Which precaution would prevent the teacher from becoming contaminated by the radioactive rocks? **(Physics only)**

Tick (✓) **one** box.

Displaying the radiation hazard symbol ☐

Handling the rocks with clean hands ☐

Wearing protective gloves ☐

(1)

(e) What is the activity of each rock after one half-life? **(Physics only)**

Tick (✓) **one** box.

The activity is a quarter of the original activity. ☐

The activity is half the original activity. ☐

The activity is double the original activity. ☐

The activity is zero. ☐

(1)

(f) How does the activity of a radioactive source affect the risk of harm from the source? **(Physics only)**

Tick (✓) **one** box.

The smaller the activity, the greater the risk of harm. ☐

The activity does not affect the risk of harm. ☐

The greater the activity, the greater the risk of harm. ☐

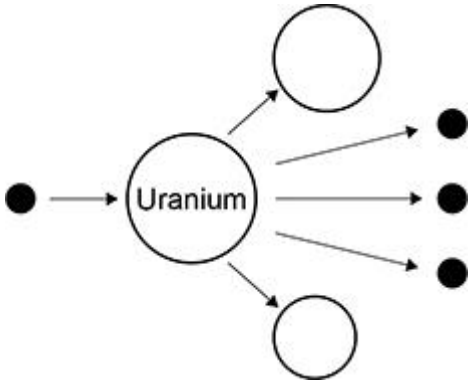
(1)

(Total 9 marks)

Q2.

The process of nuclear fission is used in nuclear power stations.

The figure below shows the process of nuclear fission.



(a) Complete the sentences.

Choose answers from the box. **(Physics only)**

electrons	**gamma rays**	**neutrons**	**nuclei**	**protons**

In nuclear power stations, energy is released from uranium

_____ .

The uranium in above figure splits into two parts and releases three

_____ .

The process of nuclear fission releases electromagnetic radiation in the form of

_____.

(3)

Use the Physics Equations Sheet to answer parts (a) and (b).

(b) Write down the equation which links energy (*E*), power (*P*) and time (*t*).

_____

(1)

(c) A nuclear power station has a power output of 500 MW.

Calculate the energy output in 3600 s.

Give your answer in J.

Energy output = _____ J

(3)

(d) Radioactive waste produced by nuclear power stations has a long half-life.

Suggest **one** precaution taken to reduce the hazard caused by radioactive waste from power stations.

(1)

(e) Nuclear power stations do **not** generate electricity every day of the year.

One nuclear power station generated electricity for 92% of a year.

one year = 365 days

Calculate the number of days during the year that the nuclear power station generated electricity.

Number of days = _____

(2)

(Total 10 marks)

Q3.

Some isotopes emit nuclear radiation.

(a) Carbon-12 and carbon-14 are both isotopes of carbon.

Complete the sentences.

Choose answers from the box.

alpha particles	**electrons**	**neutrons**	**protons**

The nucleus of a carbon-12 atom and the nucleus of a carbon-14 atom have the **same** number of _____.

The nucleus of a carbon-12 atom and the nucleus of a carbon-14 atom have a **different** number of _____.

(2)

(b) Different radioactive isotopes have different half-lives.

What does 'half-life' mean?

Tick (✓) **one** box.

Half the time taken for all of the nuclei in a sample to decay. ☐

The time taken for half the nuclei in a sample to decay. ☐

The time taken for one nucleus to split in half. ☐

(1)

(c) **Table 1** shows the half-life of some different isotopes of carbon.

Table 1

Isotope	Half-life in seconds
Carbon-15	2.45
Carbon-16	0.75
Carbon-17	0.19
Carbon-18	0.09

Which isotope is the least stable?

Tick (✓) **one** box.

Carbon-15 ☐

Carbon-16 ☐

Carbon-17 ☐

Carbon-18 ☐

(1)

(d) Workers in nuclear power stations must be aware of nuclear irradiation and radioactive contamination.

Draw **one** line from each term to an example of the term.

Term	**Example**
Radioactive contamination	Exposure to a beam of gamma rays
Nuclear irradiation	Exposure to ultraviolet radiation from the Sun
	Accidental transfer of plutonium onto a human body
	Using a mobile phone

(2)

(e) Why are workers required to walk across a sticky floor before leaving the nuclear power station?

Tick (✓) **one** box.

To remove alpha particles from their shoes. ☐

To remove gamma radiation from their shoes. ☐

To remove radioactive dust from their shoes. ☐

(1)

(f) The places where people work and live contribute to the nuclear radiation they are exposed to.

Table 2 shows the mean daily dose of radiation caused by two different jobs.

Table 2

Job	**Mean daily dose in mSv**
Aeroplane pilot	0.072
Nuclear power station worker	0.00050

Calculate the number of days a nuclear power station worker must work before receiving the same dose that an aeroplane pilot receives in one day.

_____

_____

_____

Number of days = _____

(2)

(g) The process of nuclear fission takes place in nuclear power stations.

The process of nuclear fusion takes place in the Sun.

Draw **one** line from each process to its fuel. **(Physics only)**

Process	**Fuel**
	Hydrogen
Nuclear fission	
	Iron
	Lead
Nuclear fusion	
	Uranium

(2)

(Total 11 marks)

Q4.

Radioactive isotopes emit different types of nuclear radiation.

(a) What does an alpha particle consist of?

Tick (✓) **one** box.

2 protons and 2 electrons ☐

2 protons and 2 neutrons ☐

4 protons ☐

4 neutrons ☐

(1)

(b) What is a beta particle?

Tick (✓) **one** box.

An electron ☐

A neutron ☐

Electromagnetic radiation ☐

(1)

(c) A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

What is the correct equation for this decay?

Tick (✓) **one** box.

$^{85}_{36}Kr + {}^{0}_{-1}e \longrightarrow {}^{85}_{37}Rb$ ☐

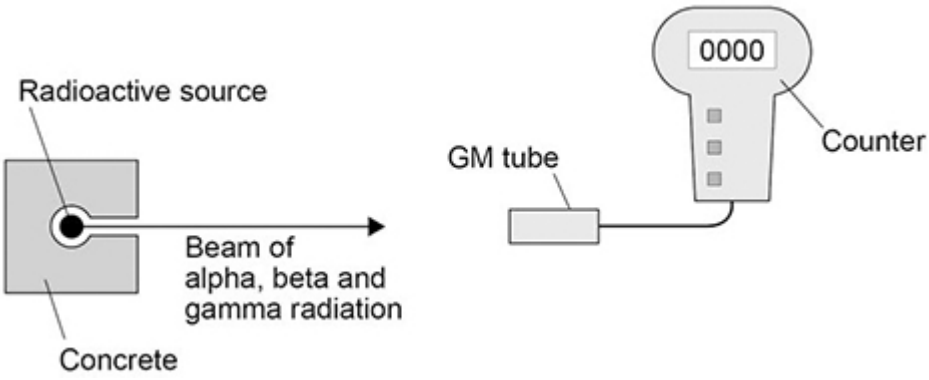
$^{85}_{36}Kr \longrightarrow {}^{85}_{37}Rb + {}^{0}_{-1}e$ ☐

$^{85}_{37}Rb \longrightarrow {}^{85}_{36}Kr + {}^{0}_{-1}e$ ☐

(1)

(d) The figure below shows an experiment to demonstrate how alpha, beta and gamma radiation penetrate different materials.

The experiment takes place in a vacuum.



Three different materials are used:

- a sheet of paper
- a 0.5 cm thick sheet of aluminium
- a 10 cm block of lead.

Each material is placed one at a time between the radioactive source and the GM tube.

The GM tube and counter show whether the material has stopped the radiation.

Complete below table to show how alpha, beta and gamma radiation penetrate the materials in the figure above.

Use the words **Yes** and **No**.

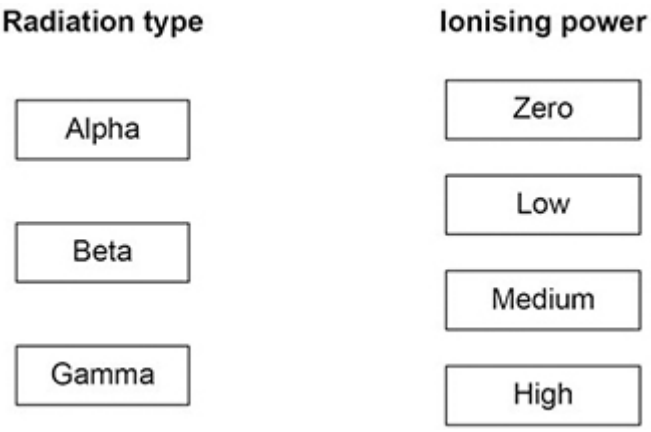
Part of below table has been completed for you.

Type of radiation	**Most radiation is stopped by:**		
	the sheet of paper	**the sheet of aluminium**	**the block of lead**
Alpha			Yes
Beta	No		
Gamma		No	

(3)

(e) Alpha, beta and gamma radiation have different ionising powers.

Draw **one** line from each radiation type to the correct ionising power.



(3)

(f) Some sources of background radiation are natural and other sources are man-made.

Which of the following is a man-made source of background radiation?

Tick (✓) **one** box.

Cosmic rays ☐

Nuclear accidents ☐

Rocks ☐

(1)

(g) The average background radiation dose per year in the UK is 2.0 millisieverts.

A dental X-ray gives a patient a radiation dose of 0.005 millisieverts.

Calculate how many dental X-rays would be the same as the average background radiation dose per year.

_____

_____

_____

Number of dental X-rays = _____

(2)

(Total 12 marks)