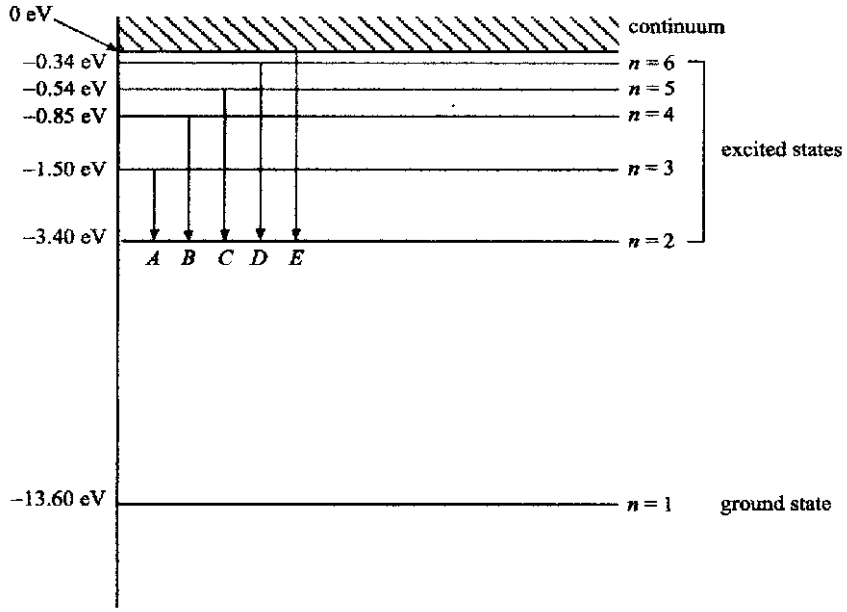
1. The energy level diagram below represents some of the transitions in an emission spectrum of a Hydrogen atom.

a. Explain how the diagram shows that energy states available to the electrons are quantised.

2 marks



b. Determine, in eV, the energy emitted by transition C above.

2 marks

c. Calculate the frequency of the photon emitted with energy of 2.55 eV.

3 marks

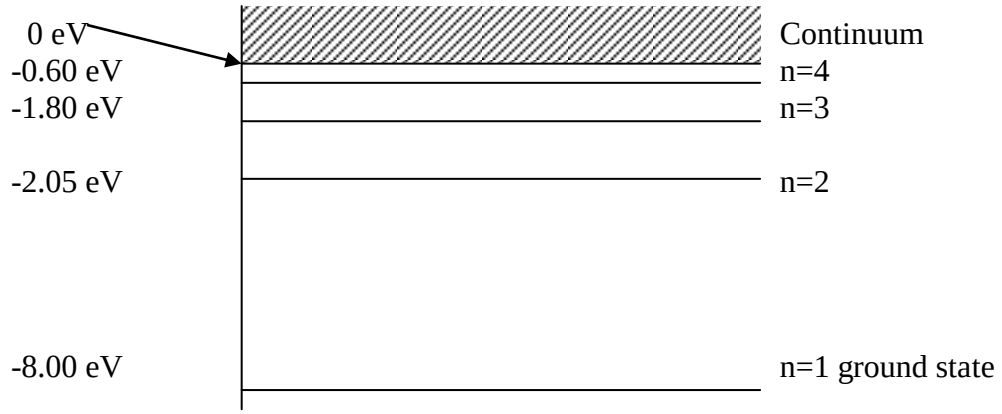
d. Name the series represented by the transitions A to E and hence determine in what part of the electromagnetic spectrum the photon will occur.

2 marks

e. Which of the transitions (A,B,C,D or E) in the emission spectrum represented above produces the shortest wavelength photon?

1 mark

2. The energy levels for an unknown element are shown below. Assume all atoms of a sample of this element are in the ground state.



a. On the energy level diagram draw two possible transitions corresponding to the *line absorption* spectrum of this element if the sample of gas is at room temperature.

2 marks

b. Determine the wavelength of the line with the smallest angle of deflection when passed through a diffraction grating, for this sample of this element. Hence calculate its wavelength.

3 marks

c. A sample of this unknown element at room temperature was exposed to photons of 3 different energy values. Determine if the following photons were likely to be absorbed. Justify your answers.
   - A photon of energy 6.20 eV
   - A photon of energy 7.00 eV
   - A photon of energy 9.00 eV

3 marks

3. Explain why the emission spectra and absorption spectra for an element will contain the same lines corresponding to particular wavelengths.

2 marks

4. Describe the structure and purpose of the main components of a helium-neon laser.

- Explain how atoms are elevated to a higher–energy excited state.
- Explain how the cavity enables the light to be amplified by repeated traverses of the laser medium.

8 marks

5. Complete and balance the following nuclear equations:

$^{226}_{88}Ra \rightarrow Rn + ^{4}_{2}\alpha + ...$

$^{27}_{13}Al + ... \rightarrow ^{27}_{12}Mg + ^{1}_{1}H$

$^{12}_{7}N \rightarrow ^{12}_{6}C + ... + ...$

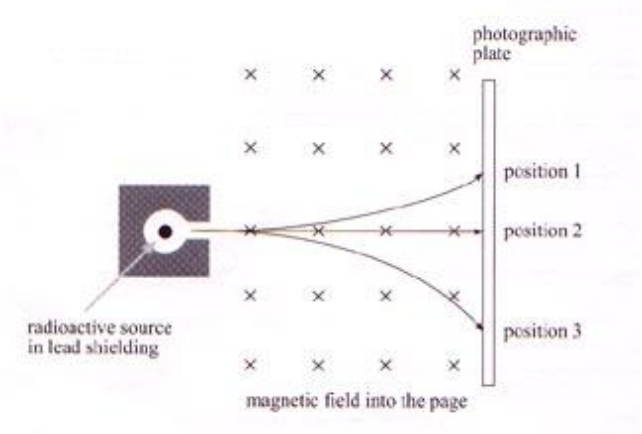
$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{90}_{36}Kr + ^{\cdots}_{\cdots}Ba + 3\,^{1}_{0}n$

4 marks

6. $^{56}_{26}Fe$ has a nuclear mass of 9.2860 x 10^{-26} kg.
Calculate its nuclear binding energy (in MeV) and hence the average binding energy per nucleon.

4 marks

7. Three distinct types of radiation are produced when a certain unstable material decays. They enter a magnetic field as illustrated below.



a) Identify each of these types of radiations.

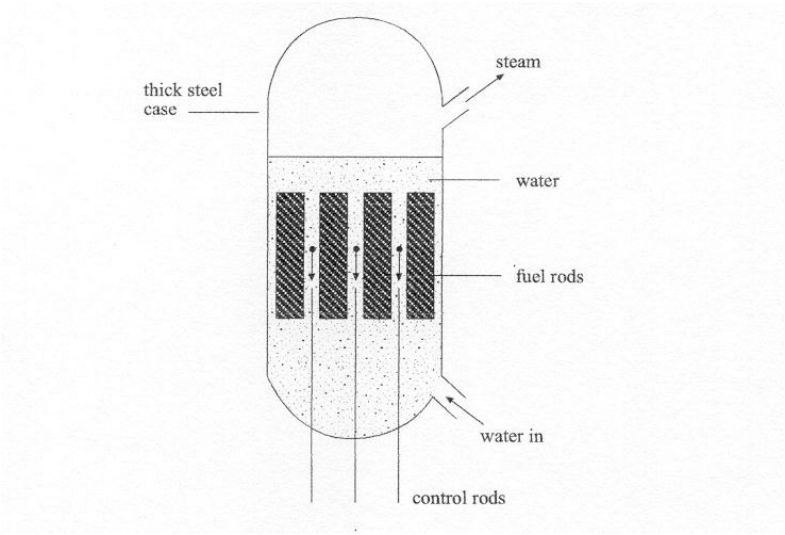
Position 1. _____ Position 2. _____Position 3._____

3 marks

b) Comment on the ionising ability of each of the three types of radiation.

3 marks

8. A diagram of a nuclear fission, water moderated power reactor is shown



a. Describe what is meant by a chain reaction in nuclear fission.

2 marks

b. The presence of a moderator is a condition for a sustained chain reaction. Explain how heavy water can be used as a moderator.

3 marks

c. Briefly describe the function and operation of the control rods

3 marks

9 A certain substance has a half-life of 20 minutes.

a Explain what the above statement means.

2 marks

b What fraction of the original material will <u>have decayed</u> after 1 hour?

2 marks

c If there was one kilogram of material originally, what mass of this will remain after 1 hour?

2 marks

d When the radiation emitted from a radioactive substance was recorded an activity count of 1200 disintegrations per minute was noted. Twenty four hours later the count was 150 per minute. What was the half life of this radioactive substance?

2 marks

10. Consider the fusion reaction ${}_1^2H + {}_1^2H \rightarrow {}_2^3He + {}_0^1n$

a. List 3 quantities conserved in this reaction.

3 marks

b. Explain why the total kinetic energy of the products is greater than the total kinetic energy of the reactants.

2 marks

c. Explain why the two reactant nuclei must have large initial kinetic energy.

2 marks

TOTAL: 65 marks