07 Atomic, Nuclear and Particle review questions

1. (a) State the properties of alpha, beta and gamma radiation (constituents, speed, penetration, ionization, mass, charge)

(b) Uranium can fission if struck by a neutron. If the energy released by such a fission reaction is 4.3MeV what statement can you make about the mass of the products formed?

2. Radium 224 decays by alpha emission into Radon 220. (Masses: Ra(224)=224.02022u, Rn(220)=220.01140u, He(4)=4.00260). Calculate the energy produced in this reaction.

3. (a) Explain the terms nuclide, nucleon, proton number Z and neutron number N.
(b) By referring to the particles contained in a nucleus explain the term isotope.
(c) Without referring to the particles contained in a nucleus explain the term isotope.

4. *Copy and complete (this goes slightly beyond required knowledge but is useful so words to use are given below – not in order)*

Nuclear stability is governed chiefly by the balance between _____ repulsion between the _____ and _____ between the protons and _____ (_____ force). The neutron:proton ratio in a small atom is __:__ to maximise the _____ _____ force but in a larger nucleus the electrostatic repulsion is more significant and the ratio _____ to __:__ to reduce this repulsion.

Words to use [protons, neutrons, strong nuclear, electrostatic, 1.5:1, 1:1, increases, attraction]

5. Write the equations for the following reactions:
a) Carbon-14 decaying by B minus radiation
b) Uranium-238 decaying by alpha radiation,
c) Lithium-6 absorbing a neutron and emitting an alpha particle.
Atomic numbers: Carbon: 6, Uranium:92, Lithium: 3.

6. The radioactivity of a sample of Protactinium was recorded using a Geiger counter and the following results were obtained:

Time interval	0-30s	60-90s	120-150s	180-210s	240-270s	300-330s	360-390s
Counts in 30s	158	98	66	50	42	37	34

(a) The background count rate without the Protactinium present was 30.
(b) (i) State one source of background radiation.
(ii) Write down the count rate due to the protactinium source and sketch a graph of this count rate against time.
(c) State and explain whether the half life of protactinium is greater or less than 60s.

7. (a) Explain how both absorption and emission spectra in elements provide evidence for the Bohr model of the atom and atomic energy levels.

(b) Describe an experiment to observe emission spectra.

(c) Determine the wavelength of the photons emitted by a Hydrogen atom when the electron moves from:

(i) n=2 state with an energy level of -3.4eV to its ground state of n=1 with an energy level of -13.6eV?

(ii) n=4 state with an energy level of -0.8eV to its ground state of n=2 with an energy level of -3.4eV?

8. The atomic mass of Nitrogen is 14 and its atomic number is 7. Rutherford bombarded Nitrogen nuclei with alpha particles and produced oxygen and released a proton. This was the first example of artificial transmutation. Write a nuclear transformation equation for this.

9. Draw and annotate a graph showing the variation with nucleon number of the binding energy per nucleon. Use this graph to account for the fact that both nuclear fusion and fission can be a source of energy.

10. (a) Write down Einstien's mass-energy equivalence relationship.

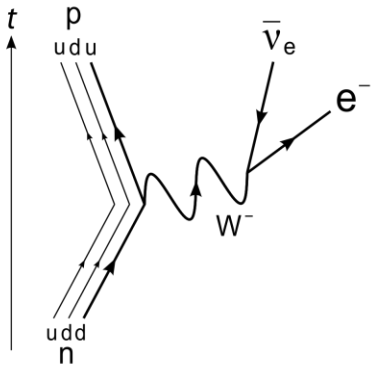
(b) The unified mass unit (u) is defined as one twelfth the mass of a Carbon 12 atom and 6.03×10^{23} of these have a mass of 12 grams.

(i) Use this data to calculate the mass of u.

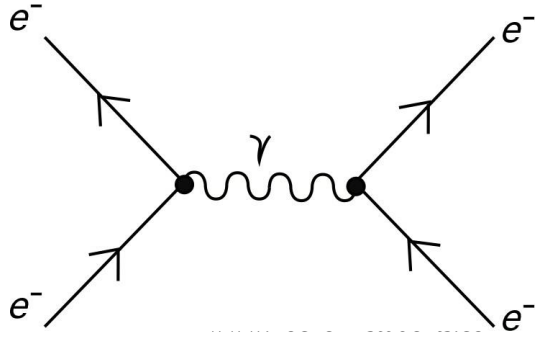
(ii) Calculate the energy equivalent of u in Joules

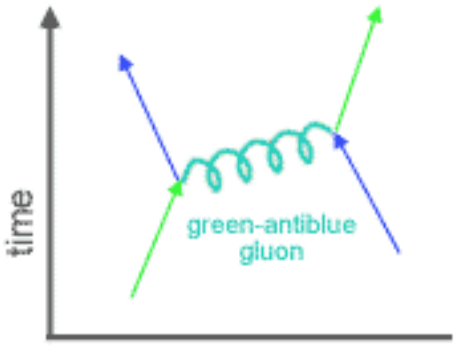
(d) Define binding energy (of a nucleus) and explain how an increase in binding energy results in a loss of mass.

11. A Feynman diagram describes the quantum dynamics of particle reactions.
The diagram opposite shows the transformation of a neutron into a proton.
(a) What is the exchange particle in this reaction?
(b) Which force acts in this reaction?
(c) Which lepton is created?
(d) Explain how lepton number is conserved.
(e) What is the baryon number before and after?



12. The diagram opposite represents the repulsion between two particles.
(a) What is the exchange particle involved?
(b) Which force acts in this interaction?





13. The diagram to the left shows interaction between quarks.

(a) This interaction might be inside which type of particle?

(b) Explain why quarks are not found on their own.