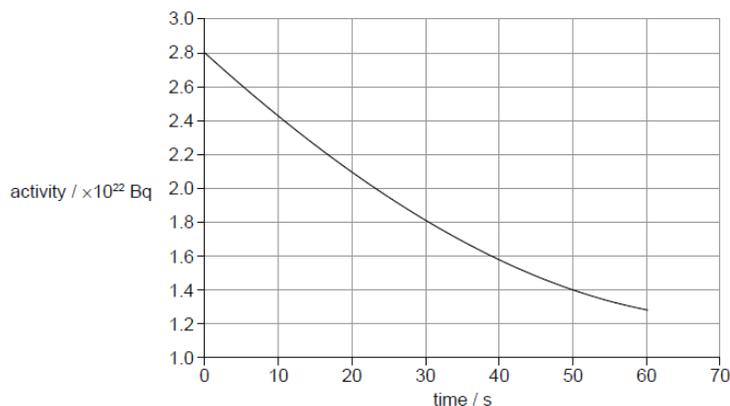


1. The graph shows the variation with time of the activity of a pure sample of a radioactive nuclide.

What percentage of the nuclide remains after 200 s?

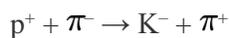
- A. 3.1 %
 B. 6.3 %
 C. 13 %
 D. 25 %



2. Copper (${}^{64}_{29}\text{Cu}$) decays to nickel (${}^{64}_{28}\text{Ni}$). What are the particles emitted and the particle that mediates the interaction?

	Particles emitted	Mediating particle
A.	β^- and neutrino	W^+
B.	β^+ and neutrino	W^-
C.	β^- and neutrino	W^-
D.	β^+ and neutrino	W^+

3. The following interaction is proposed between a proton and a pion.



The quark content of the π^- is $\bar{u}d$ and the quark content of the K^- is $\bar{u}s$.

Three conservation rules are considered: I. baryon number II. Charge III. strangeness.

Which conservation rules are violated in this interaction?

- A. I and II only
 B. I and III only
 C. II and III only
 D. I, II and III

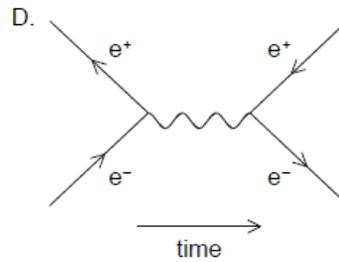
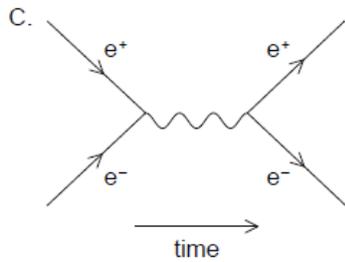
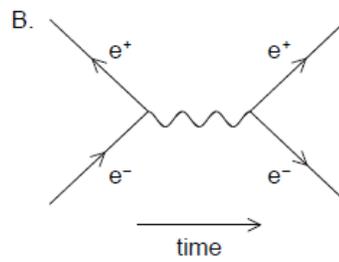
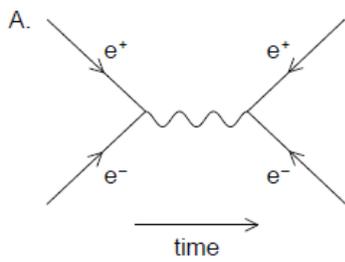
4. The following decay is observed.

$$\mu^- \rightarrow e^- + \nu_\mu + X$$

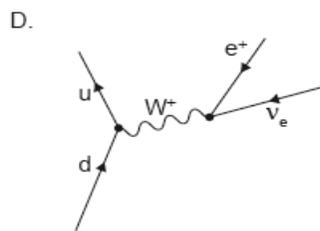
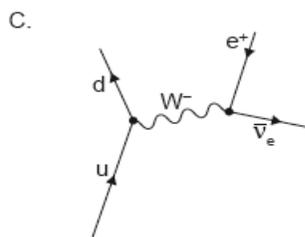
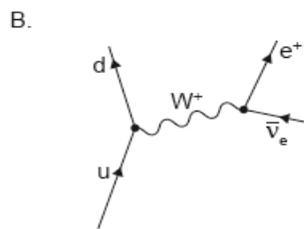
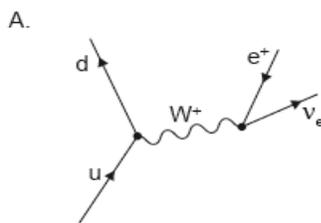
What is particle X?

- A. γ
- B. $\bar{\nu}_e$
- C. Z^0
- D. ν_e

5. Which is the correct Feynman diagram for pair annihilation and pair production?



6. Which Feynman diagram shows beta-plus (β^+) decay?

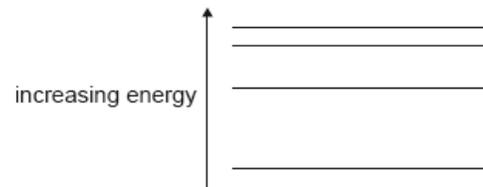


7. The average binding energy per nucleon of the $^{15}_8\text{O}$ nucleus is 7.5 MeV. What is the total energy required to separate the nucleons of one nucleus of $^{15}_8\text{O}$?
- A. 53 MeV
 B. 60 MeV
 C. 113 MeV
 D. 173 MeV

8. The energy-level diagram for an atom that has four energy states is shown.

What is the number of different wavelengths in the emission spectrum of this atom?

- A. 1
 B. 3
 C. 6
 D. 7



9. A detector, placed close to a radioactive source, detects an activity of 260 Bq. The average background activity at this location is 20 Bq. The radioactive nuclide has a half-life of 9 hours.

What activity is detected after 36 hours?

- A. 15 Bq
 B. 16 Bq
 C. 20 Bq
 D. 35 Bq

10. Element X decays through a series of alpha (α) and beta minus (β^-) emissions. Which series of emissions results in an isotope of X?

- A. 1α and $2\beta^-$
 B. 1α and $4\beta^-$
 C. 2α and $2\beta^-$
 D. 2α and $3\beta^-$

11. A graph of the variation of average binding energy per nucleon with nucleon number has a maximum. What is indicated by the region around the maximum?
- A. The position below which radioactive decay cannot occur
 - B. The region in which fission is most likely to occur
 - C. The position where the most stable nuclides are found
 - D. The region in which fusion is most likely to occur

12. Three of the fundamental forces between particles are

- I. strong nuclear
- II. weak nuclear
- III. electromagnetic.

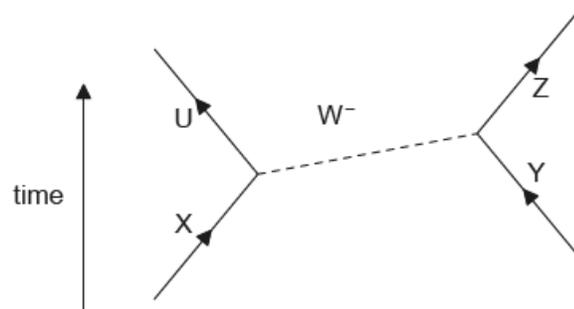
What forces are experienced by an electron?

- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
13. What is correct about the Higgs Boson?
- A. It was predicted before it was observed.
 - B. It was difficult to detect because it is charged.
 - C. It is not part of the Standard Model.
 - D. It was difficult to detect because it has no mass.

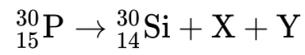
14. The Feynman diagram shows a particle interaction involving a W^- boson.

Which particles are interacting?

- A. U and Y
- B. W^- boson and Y
- C. X and Y
- D. U and X



15. A nucleus of phosphorus (P) decays to a nucleus of silicon (Si) with the emission of particle X and particle Y.



What are X and Y?

	X	Y
A.	antineutrino	positron
B.	antineutrino	electron
C.	neutrino	electron
D.	neutrino	positron

16. What is the definition of the unified atomic mass unit?

- A. $\frac{1}{12}$ the mass of a neutral atom of carbon-12
- B. The mass of a neutral atom of hydrogen-1
- C. $\frac{1}{12}$ the mass of a nucleus of carbon-12
- D. The mass of a nucleus of hydrogen-1

17. Atomic spectra are caused when a certain particle makes transitions between energy levels.

What is this particle?

- A. Electron
- B. Proton
- C. Neutron
- D. Alpha particle

18. The half-life of a radioactive element is 5.0 days. A freshly-prepared sample contains 128 g of this element. After how many days will there be 16 g of this element left behind in the sample?

- A. 5.0 days
- B. 10 days
- C. 15 days
- D. 20 days

19. The binding energy per nucleon of ${}^4_2\text{He}$ is 6 MeV. What is the energy required to separate the nucleons of this nucleus?

- A. 24 MeV
- B. 42 MeV
- C. 66 MeV
- D. 90 MeV

20. A pure sample of nuclide A and a pure sample of nuclide B have the same activity at time $t = 0$. Nuclide A has a half-life of T , nuclide B has a half-life of $2T$.

What is $\frac{\text{activity of A}}{\text{activity of B}}$ when $t = 4T$?

- A. 4
- B. 2
- C. $\frac{1}{2}$
- D. $\frac{1}{4}$