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?

B

A. 3.1 %

B. 6.3 %

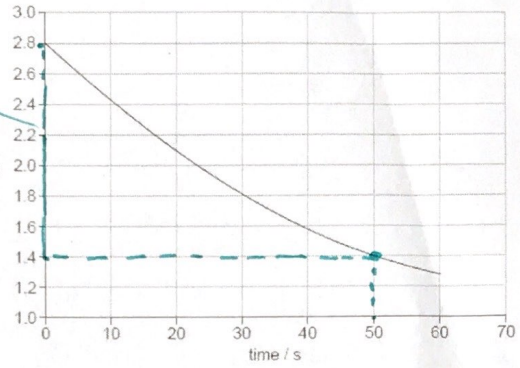
C. 13 %

D. 25 %

$\frac{1}{2}$ life to 50 sec

$\frac{200\text{ sec}}{50\text{ sec}} = 4$ half lives

1 → $\frac{1}{2}$ → $\frac{1}{4}$ → $\frac{1}{8}$ → $\frac{1}{16}$



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?

D

$^{64}_{29}Cu \rightarrow {}^{64}_{28}Ni + e^{0}_{+1} + \nu$

particle W^+

	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.

   $p^+ + \pi^- \rightarrow K^- + \pi^+$

   meson meson

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

B

   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

$p^+ \pi^- \rightarrow K^- + \pi^+$

C +1 −1 → −1 + 1 ✓

B +1 + 0 → 0 + 0 ✗

S 0 + 0 → −1 + 0 ✗

4. The following decay is observed.

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

What is particle X?

B

A. γ

B. $\bar{\nu}_e$

C. Z^0

D. ν_e

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

baryon → B	0	→	0	+	0	+ 0
charge → C	-1	→	-1	+	0	+ 0
two families: L_e	0	→	+1	+	0	− 1
two families: L_μ	+1	→	0	+	1	+ 0

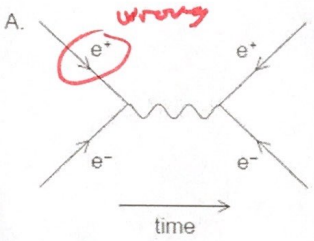
New "X" particle must satisfy these:
- Lepton - electron family
- zero charge
- "-1" lepton #

so anti electron Neutrino $\bar{\nu}_e$

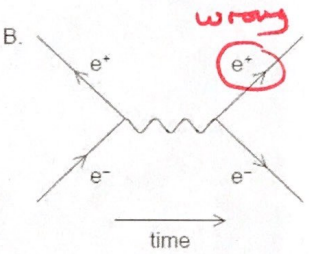
5. Which is the correct Feynman diagram for pair annihilation and pair production?

D

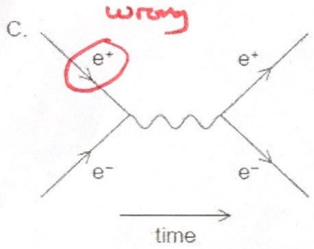
A. wrong



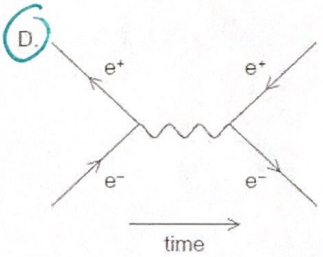
B. wrong



C. wrong



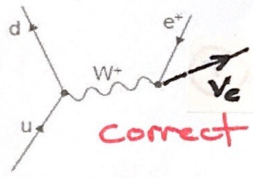
D. correct



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

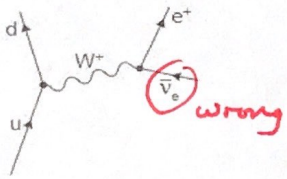
A

A.



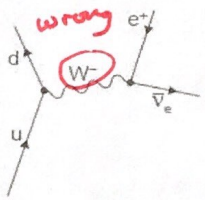
correct

B.

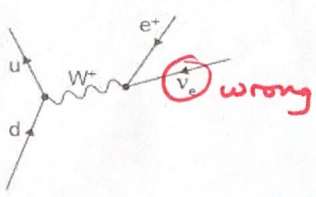


wrong

C. wrong



D.



wrong

7. The average binding energy per nucleon of the $^{15}_{8}O$ nucleus is 7.5 MeV. What is the total energy required to separate the nucleons of one nucleus of $^{15}_{8}O$?

$15 \times 7.5 = 112.5$ MeV

C

A. 53 MeV

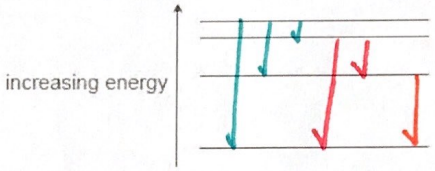
B. 60 MeV

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?



C

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?

$260 - 20 = 240$ activity

$240 \xrightarrow{9\text{ hr}} 120 \xrightarrow{9\text{ hr}} 60 \xrightarrow{9\text{ hr}} 30 \xrightarrow{9\text{ hr}} 15$ Bq

15 Bq $+ 20$ Bq $= 35$ Bq

D

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?

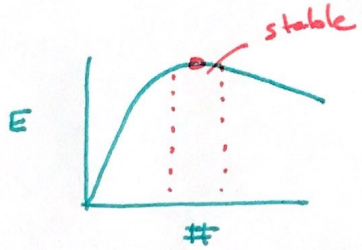
A. 1α and $2\beta^-$

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?



C

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~~ gluons II. weak nuclear III. electromagnetic.

What forces are experienced by an electron?

C

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.

A

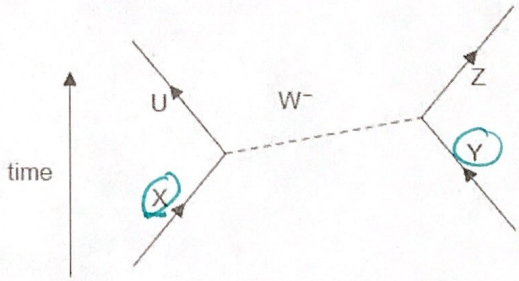
B. It was difficult to detect because it is charged.

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?



C

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.

$$^{30}_{15}\mathrm{P} \rightarrow {}^{30}_{14}\mathrm{Si} + \mathrm{X} + \mathrm{Y}$$

$^{30}_{15}P \rightarrow {}^{30}_{14}Si + {}^{0}_{+1}X + Y$ ↑ ν_e

positron e^+ → β^+ decay

What are X and Y?

D

	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

(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

(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?

128 —(5)— 64 —(5)— 32 —(5)— 16

15 days

A. 5.0 days

B. 10 days

C

C. 15 days

D. 20 days

19. The binding energy per nucleon of $^{11}_{4}Be$ is 6 MeV. What is the energy required to separate the nucleons of this nucleus?

$6 \times 11 = 66$ MeV

A. 24 MeV

C

B. 42 MeV

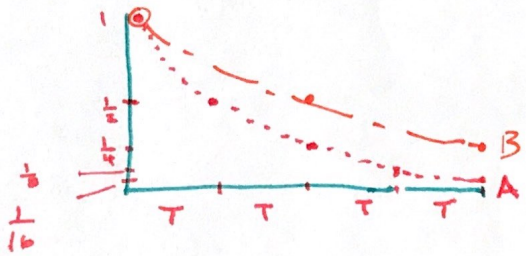
C. 66 MeV

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 $t = 4T$?

$\frac{1/16}{1/4} = \frac{1}{4}$



A. 4

B. 2

C. $\frac{1}{2}$

D

D. $\frac{1}{4}$