Ch 12 Decay and matter waves *[31 marks]*

1. Two radioactive nuclides, X and Y, have half-lives of 50 s and 100 s respectively. At time $t = 0$ samples of X and Y contain the same number of nuclei. *[1 mark]*

   What is $\frac{\text{number of nuclei of X undecayed}}{\text{number of nuclei of Y undecayed}}$ when $t = 200$ s?

   A. 4

   B. 2

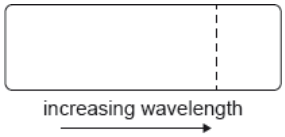
   C. $\frac{1}{2}$

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

Markscheme

D

2. According to the Bohr model for hydrogen, visible light is emitted when electrons make transitions from excited states down to the state with $n = 2$. The dotted line in the following diagram represents the transition from $n = 3$ to $n = 2$ in the spectrum of hydrogen. *[1 mark]*



   Which of the following diagrams could represent the visible light emission spectrum of hydrogen?

   A.


   B.


   C.


   D.


Markscheme

B

3. Alpha particles with energy E are directed at nuclei with atomic number Z. Small deviations from the predictions of the Rutherford scattering model are observed. *[1 mark]*

   Which change in E and which change in Z is most likely to result in greater deviations from the Rutherford scattering model?

	E	Z
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

Markscheme

B

4. Which of the following is evidence for the wave nature of the electron? *[1 mark]*

A. Continuous energy spectrum in β^- decay

B. Electron diffraction from crystals

C. Existence of atomic energy levels

D. Existence of nuclear energy levels

Markscheme

B

5. Two samples X and Y of different radioactive isotopes have the same initial activity. Sample X has twice the number of atoms as sample Y. The half-life of X is T. What is the half-life of Y? *[1 mark]*

A. $2T$

B. T

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

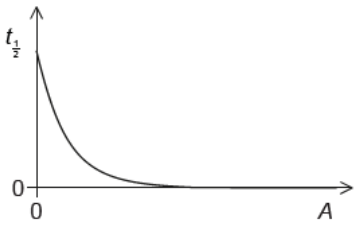
D. $\frac{T}{4}$

Markscheme

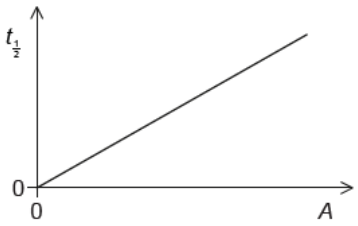
C

6. Samples of different radioactive nuclides have equal numbers of nuclei. Which graph shows the relationship between the half-life $t_{\frac{1}{2}}$ and the activity A for the samples? *[1 mark]*

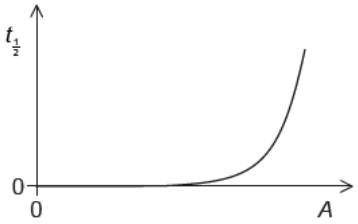
A.



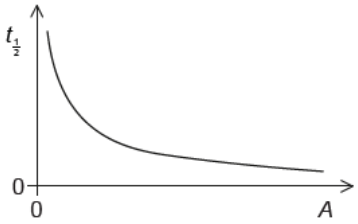
B.



C.



D.



Markscheme

D

7. Electron capture can be represented by the equation *[1 mark]*

$p + e^- \rightarrow X + Y$.

What are X and Y?

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

Markscheme

D

8. In the Bohr model for hydrogen an electron in the ground state has orbit radius *r* and speed *v*. In the first excited state the electron has orbit radius 4*r*. What is the speed of the electron in the first excited state? *[1 mark]*

A. $\frac{v}{2}$

B. $\frac{v}{4}$

C. $\frac{v}{8}$

D. $\frac{v}{16}$

Markscheme

A

9. A radioactive element has decay constant λ (expressed in s^{-1}). The number of nuclei of this element at $t = 0$ is *N*. What is the expected number of nuclei that will have decayed after 1 s? *[1 mark]*

A. $N\left(1 - e^{-\lambda}\right)$

B. $\frac{N}{\lambda}$

C. $Ne^{-\lambda}$

D. λN

Markscheme

A

10. A pure sample of mass m of a radioactive substance with half-life $T_{\frac{1}{2}}$ has an initial activity A_0. *[1 mark]*

What are the half-life and the initial activity of a pure sample of mass $2m$ of the same radioactive substance?

	Half-life	Initial activity
A.	$T_{\frac{1}{2}}$	A_0
B.	$T_{\frac{1}{2}}$	$2A_0$
C.	$2T_{\frac{1}{2}}$	A_0
D.	$2T_{\frac{1}{2}}$	$2A_0$

Markscheme

B

11. A particle has a de Broglie wavelength λ and kinetic energy E. What is the relationship between λ and E? *[1 mark]*

A. $\lambda \propto E^{\frac{1}{2}}$

B. $\lambda \propto E$

C. $\lambda \propto E^{-\frac{1}{2}}$

D. $\lambda \propto E^{-1}$

Markscheme

C

12. Which phenomenon provides evidence for the wave nature of an electron? *[1 mark]*

A. Line spectra of atoms

B. Photoelectric effect

C. Beta decay of nuclei

D. Scattering of electrons by a crystal

Markscheme

D

13. A particular radioactive substance decays and emits both β^+ particles and neutrinos. Which describes the nature of the energy spectrum of the β^+ particles and the nature of the energy spectrum of the neutrinos? *[1 mark]*

	Energy spectrum of β^+ particles	Energy spectrum of neutrinos
A.	discrete	discrete
B.	discrete	continuous
C.	continuous	discrete
D.	continuous	continuous

Markscheme

D

14. The following observations are made during nuclear decays. *[1 mark]*

I. Discrete energy of alpha particles

II. Continuous energy of beta particles

III. Discrete energy of gamma rays

Which of the observations provide evidence of the existence of nuclear energy levels?

A. I only

B. II only

C. I and III only

D. I, II and III

Markscheme

C

15. Three types of radiation emitted from radioactive materials are given below. *[1 mark]*

I. Alpha
II. Beta
III. Gamma

Which type(s) of radiation has/have a discrete energy when emitted from radioactive materials?

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

Markscheme

B

16. Which of the following is correct for the de Broglie wavelength λ of a particle when the kinetic energy of the particle is E_K? *[1 mark]*

A. $\lambda \propto \frac{1}{E_K}$

B. $\lambda \propto \frac{1}{\sqrt{E_K}}$

C. $\lambda \propto E_K$

D. $\lambda \propto {E_K}^2$

Markscheme

B

17. Three phenomena associated with nuclear and quantum physics are *[1 mark]*

I. Einstein photoelectric effect
II. de Broglie hypothesis
III. Rutherford alpha particle scattering.

Which of the phenomena can be verified by firing electrons at a metal surface?

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

Markscheme

B

18. A radioactive nuclide decays to a stable daughter nuclide. Initially the sample consists entirely of atoms of the radioactive nuclide. What fraction of the sample consists of the daughter nuclide after four half-lives? *[1 mark]*

A. $\frac{15}{16}$

B. $\frac{1}{16}$

C. $\frac{1}{8}$

D. $\frac{7}{8}$

Markscheme

A

19. An electron X is accelerated from rest through a potential difference *V*. Another electron Y is accelerated from rest through a potential difference 2*V*. After acceleration, the de Broglie wavelength of X is λ_X and that of Y is λ_Y. The speeds reached by the electrons are well below that of the speed of light. *[1 mark]*

What is the ratio $\frac{\lambda_X}{\lambda_Y}$?

A. 2

B. $\sqrt{2}$

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

D. $\frac{1}{\sqrt{2}}$

Markscheme

B

20. If there is no uncertainty in the value of the de Broglie wavelength of a particle then this means that *[1 mark]*

A. both the momentum and position of the particle are known precisely.

B. the position of the particle is known precisely but all knowledge of its momentum is lost.

C. both the energy and the position of the particle are known precisely.

D. only the momentum of the particle is known precisely but all knowledge of its position is lost.

Markscheme

D

21. An electron accelerated from rest through a potential difference *V* has de Broglie wavelength λ. What is the wavelength of an electron accelerated from rest through a potential difference of 2*V*? *[1 mark]*

A. 2*λ*

B. $\frac{\lambda}{2}$

C. $\sqrt{2\lambda}$

D. $\frac{\lambda}{\sqrt{2}}$

Markscheme

D

22. Evidence for nuclear energy levels comes from discrete energies of *[1 mark]*

I. alpha particles
II. beta particles
III. gamma ray photons.

Which of the above statements is/are **true**?

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

Markscheme

B

23. Which particles are emitted in β+ decay? *[1 mark]*

A. Positron and neutrino
B. Positron and antineutrino
C. Electron and neutrino
D. Electron and antineutrino

Markscheme

A

24. Alpha particles of charge +2 *e* and mass *m* are accelerated from rest through a potential difference *V*. Planck's constant is *h*. Which of the following gives the de Broglie wavelength of the alpha particles as a result of the acceleration? *[1 mark]*

A. $\frac{h}{mV}$

B. $\frac{h}{\sqrt{4mVe}}$

C. $\sqrt{2hmVe}$

D. *hmV*

Markscheme

B

25. An electron of mass m_e and a proton of mass m_p are moving with the same kinetic energy at non-relativistic speeds. The de Broglie wavelengths associated with the electron and the proton are λ_e and λ_p respectively. *[1 mark]*

Which of the following correctly gives the ratio $\frac{\lambda_e}{\lambda_p}$?

A. $\frac{m_p}{m_e}$

B. $\frac{m_e}{m_p}$

C. $\sqrt{\frac{m_p}{m_e}}$

D. $\sqrt{\frac{m_e}{m_p}}$

Markscheme

C

26. A positively charged particle of charge *q* and mass *m* is accelerated from rest through a potential *V*. After acceleration the de Broglie wavelength of the particle is *λ*. Which of the following is equal to *λ*? *[1 mark]*

A. $\frac{h}{\sqrt{2mqV}}$

B. $\frac{h}{\sqrt{mqV}}$

C. $\frac{hq}{\sqrt{2mV}}$

D. $\frac{hm}{\sqrt{2qV}}$

Markscheme

A

27. Electrons are accelerated from rest through a potential difference *V*. Their de Broglie wavelength is λ. The accelerating potential difference is increased to 2*V*. Which of the following gives the new de Broglie wavelength? *[1 mark]*

A. 2λ

B. $\sqrt{2}\lambda$

C. $\frac{\lambda}{\sqrt{2}}$

D. $\frac{\lambda}{2}$

Markscheme

C

28. Which of the following provides evidence for the quantization of nuclear energy levels? *[1 mark]*

I. Alpha particles have discrete values of kinetic energies

II. Gamma-ray photons have discrete energies

III. Atomic line emission spectra

1. I only
2. II only
3. I and II only
4. I, II and III

Markscheme

C

29. An electron is accelerated from rest through a potential difference V. *[1 mark]*

Which of the following is the de Broglie wavelength of the electron after acceleration?

A. $\frac{h}{\sqrt{2m_e Ve}}$

B. $\sqrt{\frac{2m_e h}{V^2}}$

C. $\frac{h}{2m_e V^2 e^2}$

D. $\frac{V^2}{2m_e h}$

Markscheme

A

30. A beam of electrons is accelerated from rest through a potential difference V. The de Broglie wavelength of the electrons is λ. For electrons accelerated through a potential difference of $2V$ the de Broglie wavelength is *[1 mark]*

A. 2λ

B. $\sqrt{2\lambda}$

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

D. $\frac{\lambda}{\sqrt{2}}$

Markscheme

D

31. The radii of nuclei can be estimated from experiments involving *[1 mark]*

A. the scattering of charged particles.

B. the Bainbridge mass spectrometer.

C. emission spectra.

D. beta particle spectra.

Markscheme

A