IB PHYSICS

Name: _____

Period: _____ Date: _____

Marks: **76** Raw Score: ____ IB Curve: ____

DEVIL PHYSICS

BADDEST CLASS ON CAMPUS

CHAPTER 12 TEST REVIEW

1. An alpha particle is accelerated through a potential difference of 10 kV. Its gain in kinetic energy is

A. 10 eV.

B. 20 eV.

C. 10 keV.

D. 20 keV.

(Total 1 mark)

2. Which of the following correctly describes the nature of the energy spectra of alpha (α), beta (β), and gamma (γ) radiation?

	α	β	γ
A.	discrete	continuous	discrete
B.	continuous	discrete	discrete
C.	discrete	discrete	continuous
D.	continuous	continuous	discrete

(Total 1 mark)

3. The energy of α-particles in α-decay and the energy of γ-rays in γ-decay are discrete. This provides evidence for the existence of

A. nuclear energy levels.

B. neutrinos.

C. atomic energy levels.

D. isotopes.

(Total 1 mark)

4. Electrons are accelerating from rest through a potential difference of V. The de Broglie wavelength λ of the electrons is proportional to which of the following?

A. V

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

C. $\sqrt{V}$

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

(Total 1 mark)

5. Which of the following is a correct statement associated with the photoelectric effect?

A. Electron emission is instantaneous.

B. Electrons are only emitted if the incident light is above a certain minimum wavelength.

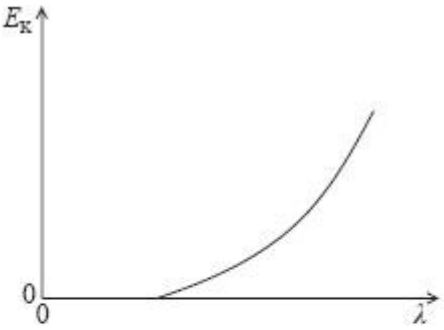
C. The energy of the emitted electrons depends on the light intensity.

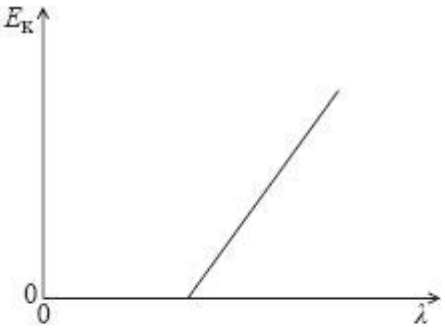
D. The energy of the emitted electrons does not depend on the frequency of the incident light.

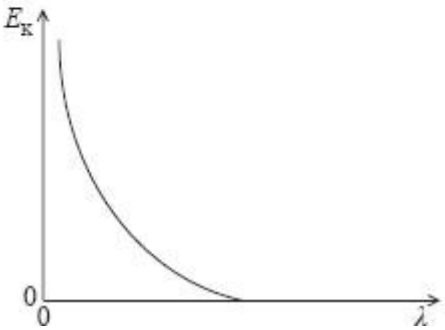
(Total 1 mark)

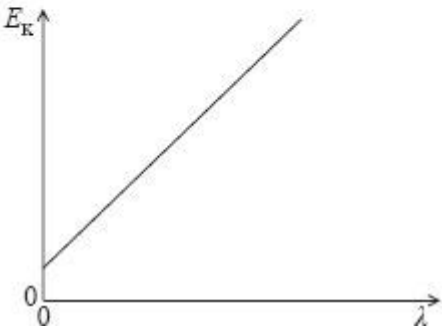
6. Light of wavelength λ is incident on a metal surface in a vacuum. Photoelectrons are emitted from the surface of the metal.

Which of the following best shows the variation with λ of the maximum kinetic energy E_K of the emitted electrons?

A. 

B. 

C. 

D. 

(Total 1 mark)

7. Light of frequency *f* is incident on a metal surface. The work function of the metal is φ. Which of the following is the maximum kinetic energy of the electrons emitted from the surface?

A. $hf - \phi$

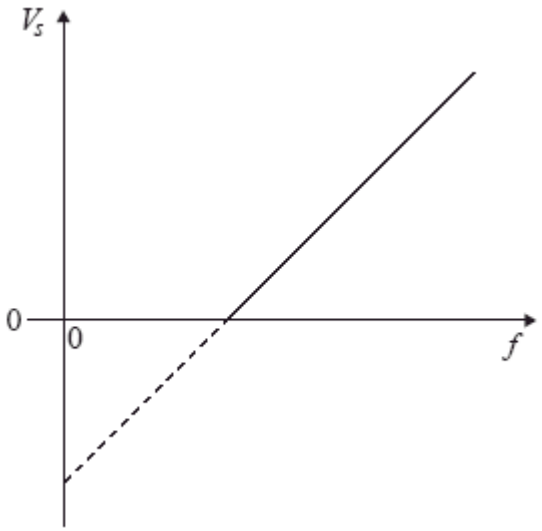
B. $\frac{h}{e}(f - \phi)$

C. $\phi - hf$

D. $\frac{h}{e}(\phi - f)$

(Total 1 mark)

8. Ultra-violet light is shone on a zinc surface and photoelectrons are emitted. The sketch graph shows how the stopping potential V_s varies with frequency f.



Planck's constant may be determined from the charge of an electron e multiplied by

A. the x-intercept.

B. the y-intercept.

C. the gradient.

D. the area under the graph.

(Total 1 mark)

9. A freshly prepared sample contains 4.0 μg of iodine-131. After 24 days, 0.5 μg of iodine-131 remain. The best estimate of the half-life of iodine-131 is

A. 8 days.

B. 12 days.

C. 24 days.

D. 72 days.

(Total 1 mark)

10. A nucleus of the isotope potassium-40 decays to a nucleus of the isotope argon-40. The reaction equation for this decay may be written as

$$^{40}_{19}\mathrm{K} \rightarrow {}^{40}_{\mathrm{Z}}\mathrm{Ar} + \mathrm{X} + \nu$$

Which of the following correctly identifies the proton number of argon-40 and the particle X?

	Z	**X**
A.	18	β^-
B.	18	β^+
C.	19	β^+
D.	19	β^-

(Total 1 mark)

11. Two samples of radioactive substances X and Y have the same initial activity. The half-life of X is T and the half-life of Y is $3T$. After a time of $3T$ the ratio

$$\frac{\text{activity of substance X}}{\text{activity of substance Y}} \text{ is}$$

A. 8.

B. 4.

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

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

(Total 1 mark)

12. A radioactive isotope has a half-life of two minutes. A sample contains sixteen grams of the isotope. How much time elapses until one gram of the isotope remains?

A. 6 minutes

B. 8 minutes

C. 10 minutes

D. 12 minutes

(Total 1 mark)

13. A radio-isotope has an activity of 400 Bq and a half-life of 8 days. After 32 days the activity of the sample is

A. 200 Bq.

B. 100 Bq.

C. 50 Bq.

D. 25 Bq.

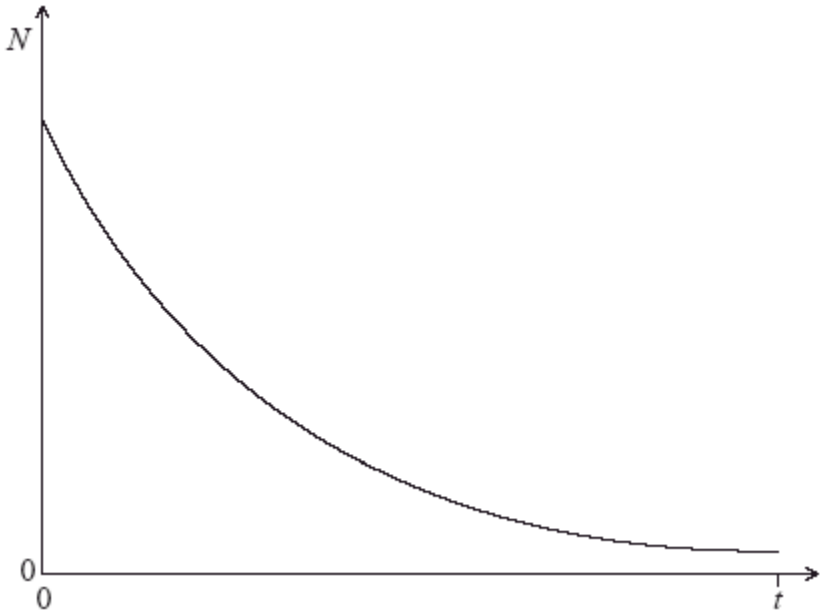
(Total 1 mark)

14. Which of the following is true in respect of both the Coulomb interaction and the strong interaction between nucleons in an atom?

	Coulomb interaction exists between	**Strong interaction exists between**
A.	protons only	neutrons only
B.	both protons and neutrons	neutrons only
C.	protons only	both protons and neutrons
D.	both protons and neutrons	both protons and neutrons

(Total 1 mark)

15. The graph below shows the number of nuclei N of a radioactive isotope as a function of time t.



The slope of the curve at any given time is

A. independent of the decay constant.

B. proportional to the half-life of the isotope.

C. proportional to the number of radioactive nuclei remaining at that time.

D. proportional to the number of radioactive nuclei decayed.

(Total 1 mark)

16. Which of the following provides evidence for de Broglie's hypothesis concerning matter waves?

A. Electron diffraction

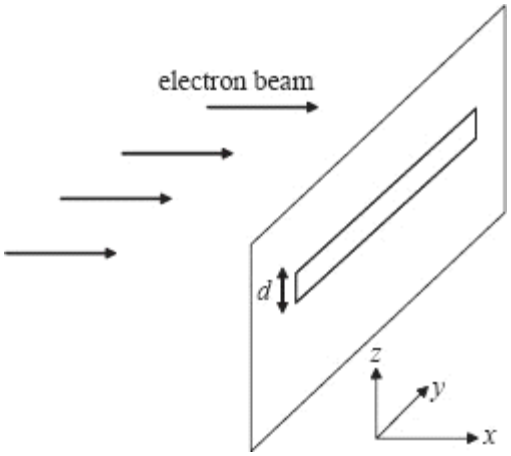
B. Atomic energy levels

C. Nuclear energy levels

D. The photoelectric effect

(Total 1 mark)

17. A beam of electrons of uniquely defined wavelength λ is incident on an aperture of height d. The beam is travelling along the x direction. The height d is of the same order as λ.



After passing through the aperture, the component of momentum in the x direction is p_x and the component in the z direction is p_z. Which of the following shows the uncertainty in p_x and the uncertainty in p_z?

	Δp_x	Δp_z
A.	0	0
B.	0	$\frac{h}{4\pi d}$
C.	$\frac{h}{4\pi d}$	0
D.	$\frac{h}{4\pi d}$	$\frac{h}{4\pi d}$

(Total 1 mark)

18. This question is about alpha (α) particle scattering.

An experiment is carried out in which alpha (α) particles of initial kinetic energy 5.0 MeV are fired at a piece of gold foil. The proton number of gold is 79.

Determine the distance of closest approach of an alpha (α) particle to a gold nucleus.

.....

.....

.....

.....

.....

.....

.....

.....

(Total 4 marks)

19. This question is about wave–particle duality.

(a) In the photoelectric effect, electrons are not emitted from the surface of a metal if the frequency of the incident light is below a certain value called the threshold frequency.

(i) Explain, with reference to the Einstein model of the photoelectric effect, the existence of the threshold frequency.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)

(ii) State, with reference to your answer in (a)(i), the reason why the threshold frequency is different for different metals.

.....

.....

(1)

(b) Light of frequency 1.0×10^{15} Hz is incident on the surface of a metal. The work function of the metal is 3.2×10^{-19} J.

(i) Show that the maximum kinetic energy of the emitted electrons is 3.4×10^{-19} J.

.....

.....

.....

.....

(2)

(ii) Determine the de Broglie wavelength of the electrons in (b)(i).

.....

.....

.....

.....

.....

(3)

20. This question is about the photoelectric effect.

(a) State what is meant by the photoelectric effect.

.....

.....

.....

(1)

(b) Light of frequency 8.7×10^{14} Hz is incident on the surface of a metal in a photocell. The surface area of the metal is 9.0×10^{-6} m^2 and the intensity of the light is 1.1×10^{-3} W m^{-2}.

(i) Deduce that the maximum possible photoelectric current in the photocell is 2.7 nA.

.....

.....

.....

.....

.....

.....

(3)

(ii) The maximum kinetic energy of photoelectrons released from the metal surface is 1.2 eV. Calculate the value of the work function of the metal.

.....

.....

.....

(1)

21. This question is about the de Broglie hypothesis.

(a) State the de Broglie hypothesis.

.....

.....

.....

.....

.....

(2)

(b) Determine the de Broglie wavelength of a proton that has been accelerated from rest through a potential difference of 1.2 kV.

.....

.....

.....

.....

.....

(2)

(c) Explain why a precise knowledge of the de Broglie wavelength of the proton implies that its position cannot be observed.

.....

.....

.....

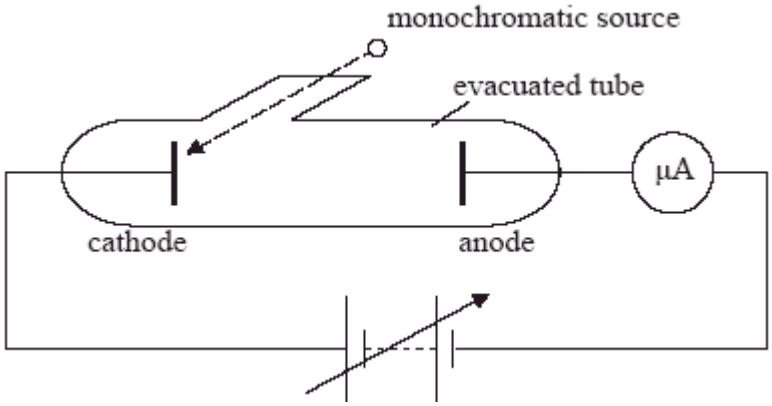
.....

.....

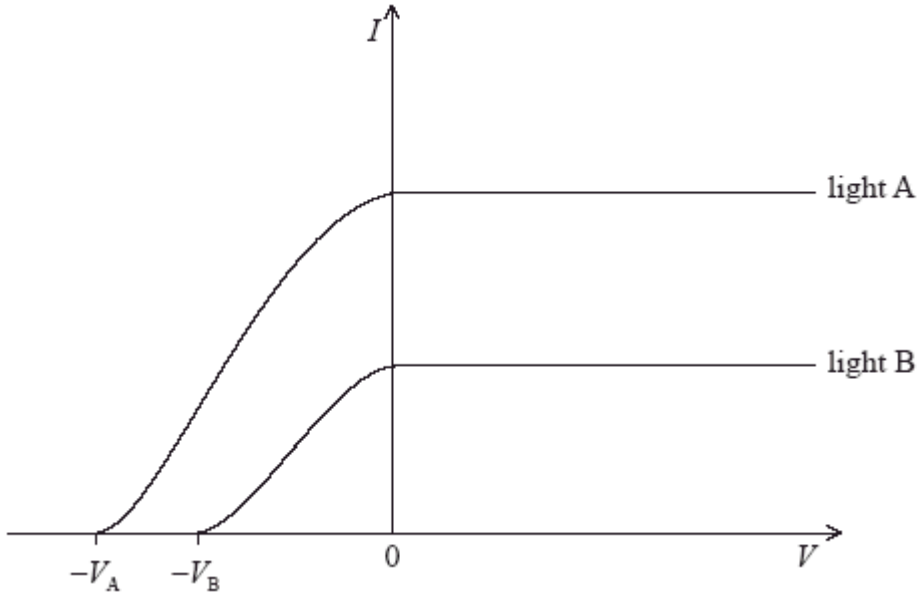
(2)

22. This question is about photoelectric effect and de Broglie wavelength.

The diagram is a representation of apparatus used to study the photoelectric effect.



Light from the monochromatic source is incident on a cathode placed in an evacuated tube.
A variable voltage supply is connected between anode and cathode and the photoelectric current is registered by the microammeter. The sketch graph shows how the photoelectric current *I* varies with the potential difference *V* between anode and cathode for two sources of light, A and B, of different frequencies and intensities.



(a) Explain with reference to the Einstein model, which graph, A or B, corresponds to the light with the greater frequency.

.....

.....

.....

.....

.....

.....

.....

.....

(4)

(b) The frequency of the light that produces graph A is 8.8×10^{14} Hz. The magnitude of V_A is 1.6 V.

(i) State the value of the maximum energy, in eV, of the electrons emitted from the cathode.

.....

(1)

(ii) Determine the work function, in eV, of the surface of the cathode.

.....

.....

.....

.....

(2)

(c) The frequency of the incident light is increased but the intensity remains constant.
Explain why this increase in frequency results in a change to the maximum photoelectric current (saturation current).

.....

.....

.....

.....

.....

.....

(3)

(d) The electrons emitted from the photo-cathode have an associated de Broglie wavelength.
Describe what is meant by the de Broglie wavelength.

.....

.....

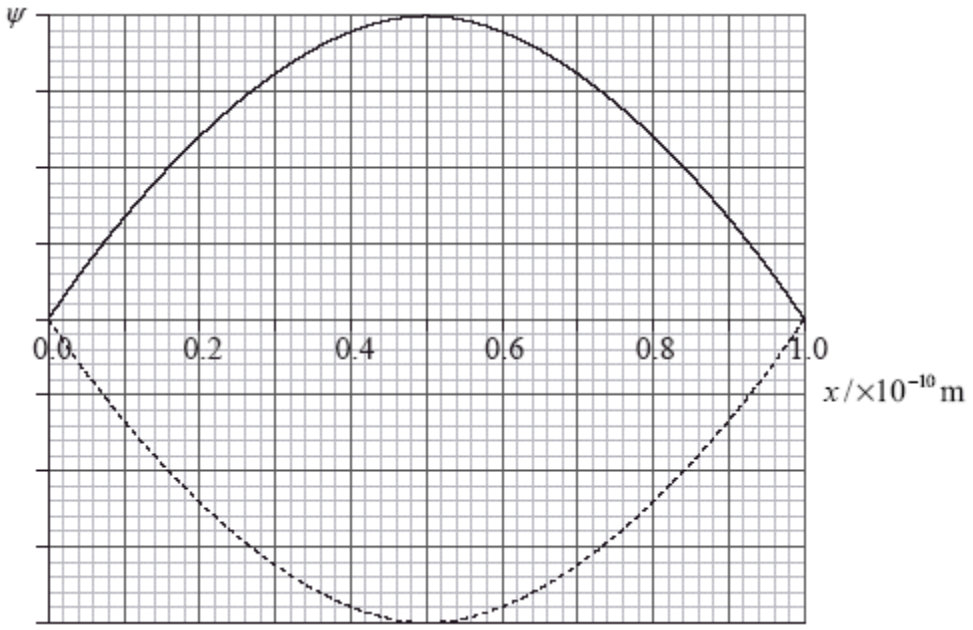
.....

.....

(2)

23. This question is about quantum aspects of the electron.

The wavefunction ψ for an electron confined to move within a "box" of linear size $L = 1.0 \times 10^{-10}$ m, is a standing wave as shown.



(a) State what is meant by a wavefunction.

.....

.....

(1)

(b) State the position near which this electron is most likely to be found.

.....

.....

(1)

(c) Calculate the momentum of the electron.

.....

.....

.....

.....

(2)

(d) The energy, in joules, of the electron in a hydrogen atom, is given by $E = -\frac{2.18 \times 10^{-18}}{n^2}$ where n is a positive integer. Calculate the wavelength of the photon emitted in a transition from the first excited state of hydrogen to the ground state.

.....

.....

.....

.....

.....

.....

(3)

(e) The electron stays in the first excited state of hydrogen for a time of approximately $\Delta t = 1.0 \times 10^{-10}$ s.

(i) Determine the uncertainty in the energy of the electron in the first excited state.

.....

.....

.....

.....

(2)

(ii) Suggest, with reference to your answer to (e)(i), why the photons emitted in transitions from the first excited state of hydrogen to the ground state will, in fact, have a small range of wavelengths.

.....

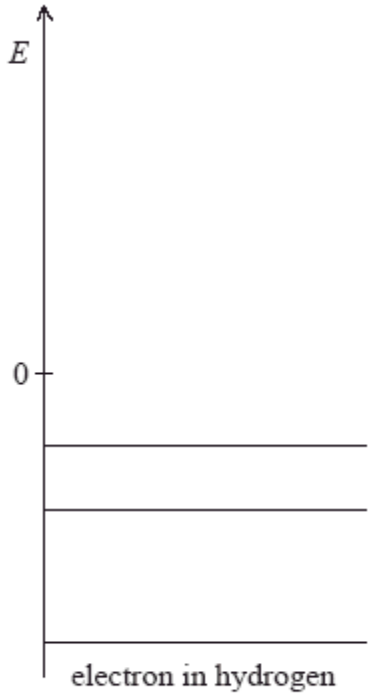
.....

.....

.....

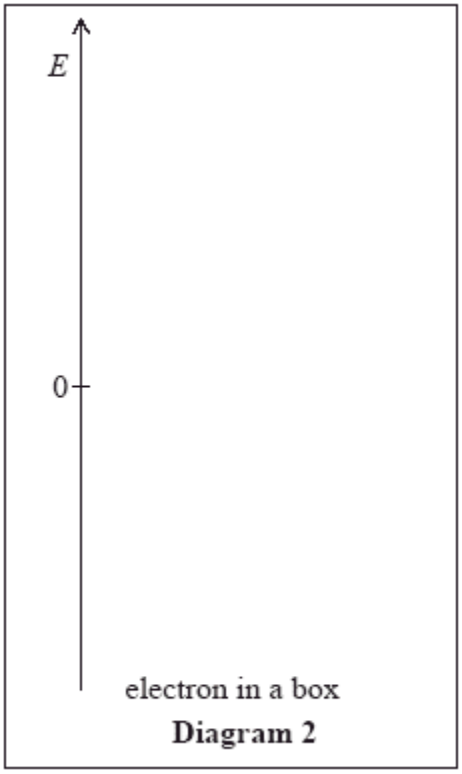
(2)

(f) Diagram 1 shows the three lowest energy levels for an electron in the hydrogen atom.



electron in hydrogen

Diagram 1



electron in a box

Diagram 2

Using the energy axis on diagram 2, draw the three lowest energy levels for the electron in a box model. You do not have to put any numbers on the vertical axis.

(2)

24. This question is about radioactive decay.

Nitrogen-13 ($^{13}_{7}\mathrm{N}$) is an isotope that is used in medical diagnosis. The decay constant of nitrogen-13 is $1.2 \times 10^{-3}\ \mathrm{s}^{-1}$.

(a) (i) Define *decay constant*.

.....

.....

.....

(1)

(ii) A sample of nitrogen-13 has an initial activity of 800 Bq. The sample cannot be used for diagnostic purposes if its activity becomes less than 150 Bq. Determine the time it takes for the activity of the sample to fall to 150 Bq.

.....

.....

.....

.....

(2)

(b) (i) Calculate the half-life of nitrogen-13

.....

.....

.....

(1)

(ii) Outline how the half-life of a sample of nitrogen-13 can be measured in a laboratory.

.....

.....

.....

.....

.....

(3)

(c) Nitrogen-13 undergoes β^+ decay. Outline the experimental evidence that suggests another particle, the neutrino, is also emitted in the decay.

.....

.....

.....

.....

.....

(2)