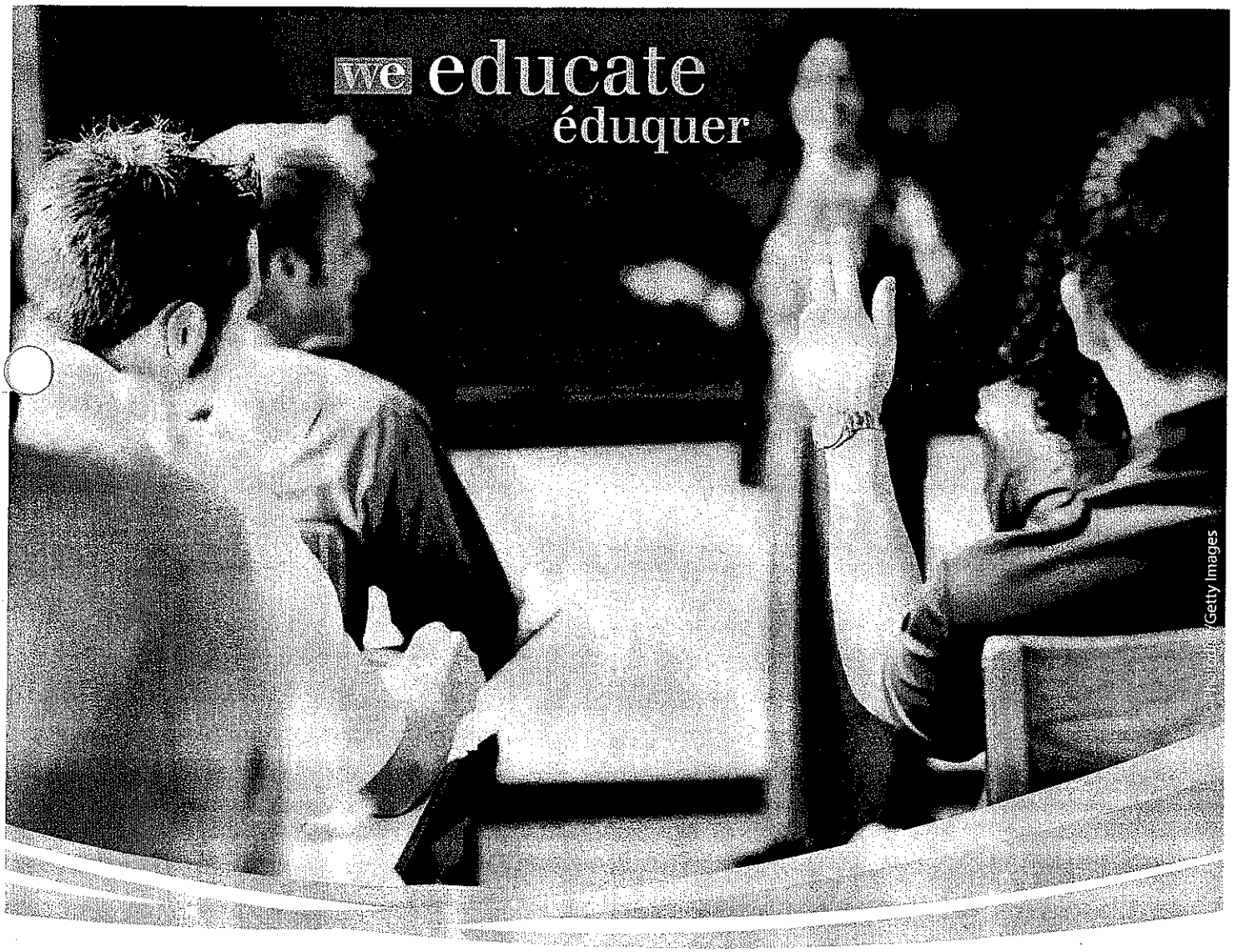
Key

Physics 30 | Released Items

2008 Released Diploma Examination Items



Alberta Education

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To call toll-free from outside Edmonton, dial 310-0000.

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Introduction

The questions presented in this booklet are from Physics 30 diploma examinations and field tests. This material, along with the *Program of Studies*, *Subject Bulletin*, and *Assessment Highlights*, may provide insights that assist you with decisions relative to instructional programming.

Both stand-alone items and items that are in scenario are included. Although these items have been field tested under the old program of studies, they are appropriate to the *Physics 20–30, 2007 Program of Studies*.

These items, in both English and French, are released by Learner Assessment and may be used by the classroom teacher as review for students. These questions do not cover the full program of studies and are not distributed across difficulty levels that would allow this to be a valid stand-alone assessment tool.

Released items are available in print form only and are not available electronically because of copyright limitations.

Information on Released Machine-Scored Questions

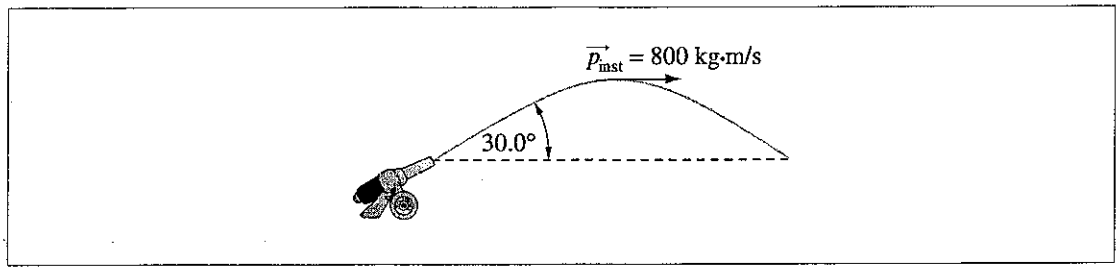
The following table gives results for 24 machine-scored questions: for each question, the percentage of students getting the question correct (item difficulty), the keyed answer, Program of Studies Outcome(s) for the *Physics 20–30, 2007 Program of Studies*, and its location on a previous diploma examination (month and year) or field test (FT and year).

Key: MC—Multiple Choice; NR—Numerical Response

Item #	% Correct	Key	Knowledge Outcome	Skill Outcome	STS Outcome	Location
MC 1	50.9	B	A1.1k			FT June 2004
MC 2	45.3	A	A1.2k	A1.3s		FT June 2001
MC 3	48.9	C	A1.4k	A1.3s		FT June 2007
MC 4	66.5	C	A1.4k	A1.3s		June 2006
MC 5	49.5	C	B1.2k	B1.3s		FT Jan 2008
MC 6	52.9	C	B1.2k			FT Jan 2008
MC 7	82.7	A	B1.2k	B2.3s		FT Jan 2008
MC 8	50.0	C	B2.9k	B2.3s		FT June 2006
MC 9	48.9	B	B1.1k			FT June 2006
MC 10	54.7	B	B1.6k			FT Jan 2006
MC 11	67.9	D	B1.6k			FT Jan 2006
MC 12	63.7	B	B26k			FT June 2007
NR 1	57.2	1.26	B2.9k	B2.3s		FT June 2007
NR 2	5833	66.0	B3.5k	B3.3s		FT June 2007
MC 13	89.1	B	C2.1k			FT June 2007
MC 14	57.6	B	B2.6k	B2.2s		FT June 2007
MC 15	29.4	A	B3.6k	B3.3s		FT June 2007
MC 16	48.4	B	D2.1k			June 2004
MC 17	80.2	B	D2.6k			Aug 2004
MC 18	68.2	C	D3.2k			FT June 2007
MC 19	79.8	A	D3.3k			FT June 2007
MC 20	38.0	D	C2.1k			FT June 2007
NR 3	26.1	2346	D3.5k			FT Jan 2004
MC 21	72.0	D	D4.1k		NS1	FT Jan 2008

24 questions $\frac{1393.9}{24} = 58.1\%$

Use the following information to answer the first question.



1. A 2.00 kg cannonball is fired out of a cannon at an angle of 30.0° to the horizontal. When the cannonball reaches the top of its path, its momentum has a magnitude of 800 kg·m/s. What was the horizontal component of the cannonball's momentum when it left the cannon?

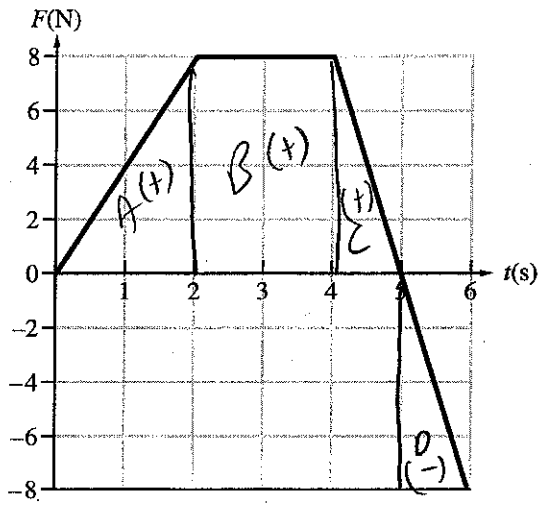
A. 461 kg·m/s
B. 800 kg·m/s
C. 924 kg·m/s
D. 1 600 kg·m/s

projectile motion → x - uniform
y - accelerated

The horizontal component of the cannonballs' $\vec{p}$ remains constant throughout the time it is in the air.

Use the following information to answer the next question.

Force on a Ball as a Function of Time



2. The net impulse delivered to the ball from $t = 0.0$ s to $t = 6.0$ s is

A. 24 N·s
B. 28 N·s
C. 32 N·s
D. 48 N·s

Impulse = $F\Delta t$ = area

Impulse = area A + area B

Impulse = $\frac{1}{2}bh + l \times w$

Impulse = $\frac{1}{2} 2 \times B + 2 \times B$

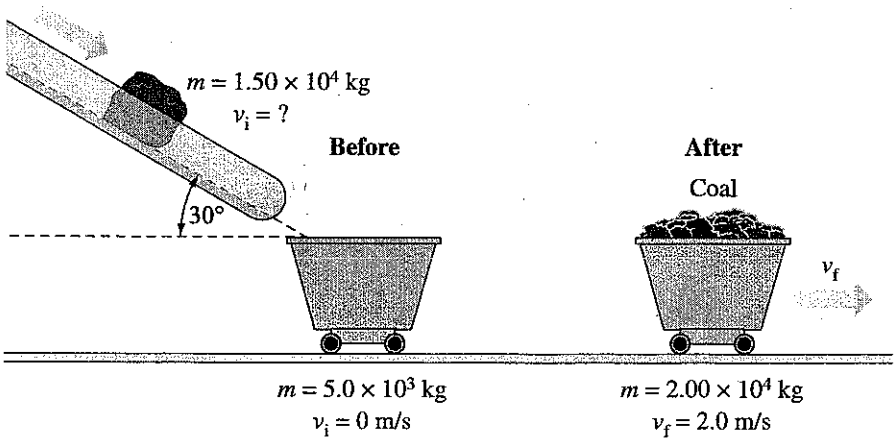
Impulse = 8 N·s + 16 N·s

Impulse = 24 N·s

note
C and D cancel
+ −

Use the following information to answer the next question.

A coal chute angled at 30° to the horizontal releases 1.50×10^4 kg of coal to fill a stationary, empty 5.0×10^3 kg cart. The cart and coal move forward with a horizontal velocity of 2.0 m/s.



1D collision - use derived formula (inelastic)

3. The speed of the coal along the chute is

A. 1.5 m/s.
B. 2.7 m/s
C. 3.1 m/s
D. 5.3 m/s

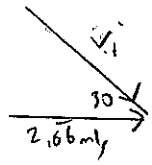
$p_{before} = p_{after}$

$m_A v_A + m_B v_B = (m_A + m_B) v'$

$1.50 \times 10^4 \text{ kg}\, v_A + 0 = (2.00 \times 10^4 \text{ kg})\, 2.0 \text{ m/s}$

$v_A = \dfrac{4.0 \times 10^4 \text{ kg·m/s}}{1.5 \times 10^4 \text{ kg}}$

$v_A = 2.666 \text{ m/s}$



$\cos 30 = \dfrac{2.66}{v_i}$

$v = 3.1 \text{ m/s}$

Use the following information to answer the next question.

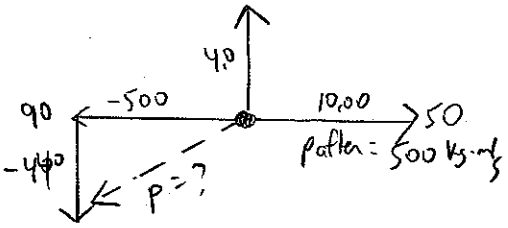
A hole is drilled in a boulder that has a mass of 250.0 kg. An explosive charge is placed in the hole. The boulder explodes into three main pieces that have masses of 110.0 kg, 50.0 kg, and 90.0 kg. The 110.0 kg piece and the 50.0 kg piece fly off at right angles to each other at speeds of 4.00 m/s and 10.00 m/s, respectively.

(110) $p_{after} = 440$ kg·m/s

2D explosion - find x and y momentum of 3rd fragment

4. The magnitude of the momentum of the 90.0 kg piece is

A. 7.40 kg·m/s
B. 60.0 kg·m/s
C. 666 kg·m/s
D. 940 kg·m/s



$p_{x\,before} = p_{x\,after}$

$0 = 0 + 500 + ?_x$

$-500 = ?_x$

$p_{y\,before} = p_{y\,after}$

$0 = 440 + 0 + ?_y$

$-440 = ?_y$

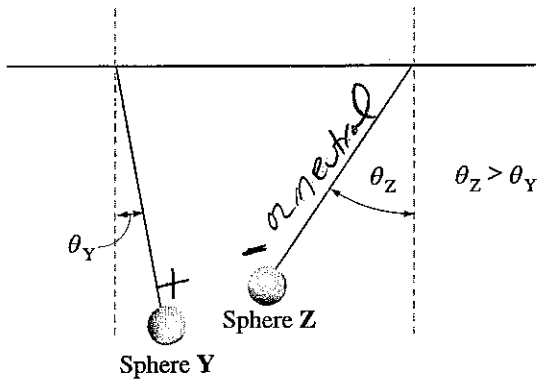
$a^2 + b^2 = c^2$

$(-500)^2 + (-440)^2 = c^2$

$666 \text{ kg·m/s} = c$ (if you were asked for speed you would ÷ by 90 kg)

Use the following information to answer the next three questions.

In an electrostatics demonstration, a teacher uses two graphite-coated spheres, Y and Z, that are suspended on insulating threads. She tells the students that sphere Y is positively charged. She does not provide any information about sphere Z. The spheres hang in equilibrium as shown below. The angle θ_Z is greater than the angle θ_Y.



5. Which of the following conclusions comparing either the charges present on spheres Y and Z or the masses of spheres Y or Z is supported?

A. Sphere Y has more charge than sphere Z and is therefore deflected from the vertical by a smaller angle.

B. Sphere Z has more charge than sphere Y and is therefore deflected from the vertical by a larger angle.

C. Sphere Y has more mass than sphere Z and is therefore deflected from the vertical by a smaller angle.

D. Sphere Z has more mass than sphere Y and is therefore deflected from the vertical by a larger angle.

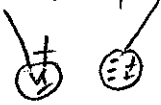
Remember Newton's 3rd law F_Y exerts on Z $= F_Z$ exerts on Y

If the same force acts on Y and Z, but Y is deflected less ... then Y must be more massive.

6. The nature of the charge on sphere Z **must** be

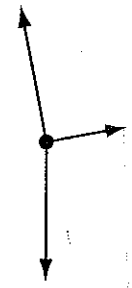
A. positive only
B. negative only
C. either positive or neutral
D. either negative or neutral

a + charge (Y) will attract a negative charge (law of charges) or a neutral sphere (charging by induction)



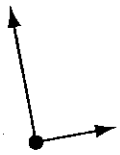
7. Which of the following free-body diagrams **most closely** represents the forces acting on sphere Y?

A.

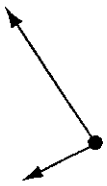


B.

C.



D.

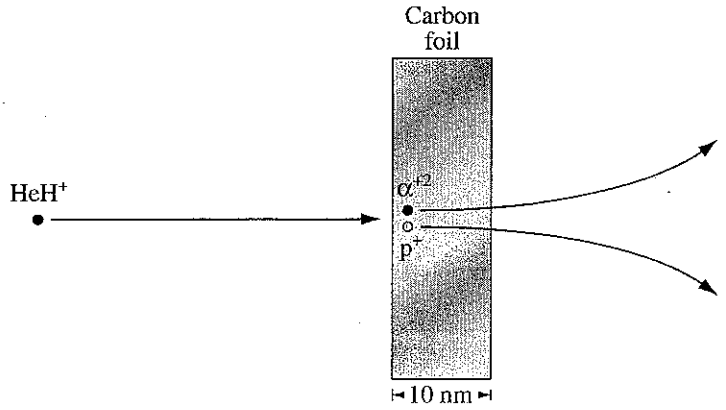


F_T (resultant) =

Use the following information to answer the next four questions.

Coulomb Explosion

A Coulomb explosion occurs when a high-energy complex ion is brought to rest in a collision with a solid object. In one such collision, a helium–hydrogen ion, HeH^+, collides with a carbon foil target. During this collision, all of the electrons are stripped from the incident helium–hydrogen ion. The ion splits into an alpha particle, α^{2+}, and a proton, p^+.



Properties of a Helium–Hydrogen Ion (HeH^+)

Kinetic energy before collision	3.00 MeV
Length of helium–hydrogen bond	8.00×10^{-11} m
Mass	8.32×10^{-27} kg

Energies of Scattered Particles

Alpha particle	2.20 MeV
Proton	0.600 MeV

Electrons and electromagnetic radiation are also detected. energy must be 0.200 MeV

means voltage

8. The minimum electric potential difference required to accelerate the helium–hydrogen ions from rest is

A. 3.00 eV energy unit

B. 3.00 MeV energy unit

C. 3.00 MV voltage unit

D. 3.00 MJ energy unit

$\Delta E_p = \Delta E_K$

$qV = \Delta E_K$

$1.6\times10^{-19}\,C \times V = 3.00\times10^{6}\,eV \times \frac{1.6\times10^{-19}\,J}{eV}$

$V = \frac{4.8\times10^{-13}\,J}{1.6\times10^{-19}\,C}$

$V = 3.0\times10^{6}\,\frac{J}{C}$ or Volts

9. The conservation principle that is necessary to predict the number of electrons that should be produced when one helium–hydrogen ion (HeH^+) turns into an alpha particle and a proton is the conservation of

A. mass
B. charge
C. energy
D. momentum

$HeH^+ \rightarrow \alpha^{2+} + p^+$

net charge is $+1$ $\rightarrow$ net charge is $+3$ so 2 electrons ($2e^-$) must be produced.

10. The electrostatic force of repulsion of the alpha particle and the proton on each other immediately after the collision is

use Coulomb's Law

A. 3.60×10^{-8} N
B. 7.19×10^{-8} N
C. 2.88×10^{-18} N
D. 5.75×10^{-18} N

$$F_{el} = \frac{k q_1 q_2}{r^2} = \frac{8.99\times10^9 \cdot (3.2\times10^{-19})(1.6\times10^{-19})}{(8.00\times10^{-11}\ m)^2} = 7.19\times10^{-8}\ N$$

11. As the alpha particle and proton move apart the electrostatic force varies

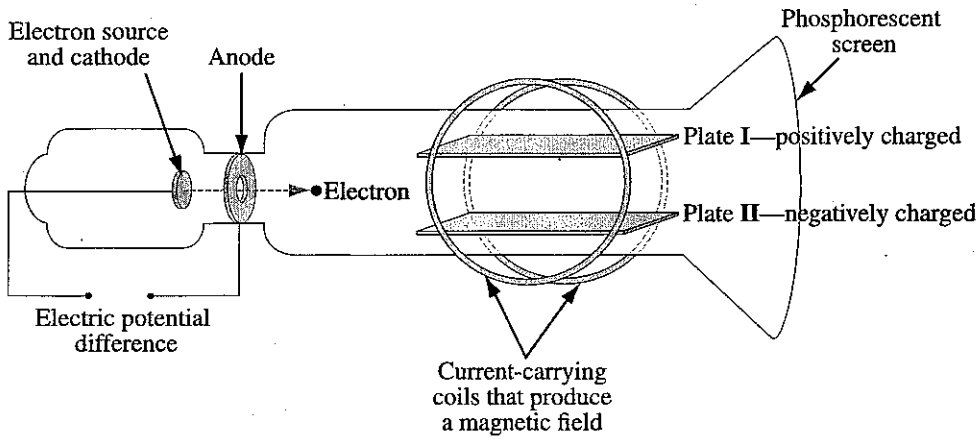
A. directly with the distance between the particles
B. inversely with the distance between the particles
C. directly as the square of the distance between the particles
D. inversely as the square of the distance between the particles

$$F_{el} = \frac{k q_1 q_2}{r^2}$$

$F_{el} \propto \frac{1}{R^2}$ so ... as the particles move further apart, the repulsive force between them becomes WEAKER eg twice as far apart $F_{el} \propto \frac{1}{2^2} \propto \left(\frac{1}{4}\right)$ three times as far $F_{el} \propto \frac{1}{3^2} \propto \left(\frac{1}{9}\right)$ etc

Use the following information to answer the next six questions.

An investigation is performed using the apparatus shown below. Electrons are accelerated from rest from the cathode by an electric potential difference. The cathode and anode are 2.00×10^{-2} cm apart. The electrons reach a speed of 2.10×10^{7} m/s as they pass through the hole in the anode.



Electrons then pass undeflected through a region in which there is both an electric and a magnetic field. The electric field is produced between plate I and plate II, which are 3.00 cm apart. The electric potential difference between the plates is 12.0 V. Two current-carrying coils produce a magnetic field that is perpendicular to the electric field.

Numerical Response

means voltage

1. The electric potential difference between the cathode and the anode, expressed in scientific notation, is _____ $\times 10^{w}$ V.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

$\Delta E_{p\,electrical} = \Delta E_k$

$qV = \frac{1}{2}mv^2$

$1.60 \times 10^{-19} \cdot V = \frac{1}{2} 9.11 \times 10^{-31} \cdot (2.10 \times 10^{7})^2$

$V = \frac{2.008 \times 10^{-16}\ J}{1.60 \times 10^{-19}\ C}$

$V = 1.26 \times 10^{3}\ V$

12. The electric field between plate I and plate II is

uniform $|\vec{E}|$ so

$|\vec{E}| = \frac{V}{d} = \frac{120V}{0.030m}$

$|\vec{E}| = 400\frac{V}{m}$

A. 4.00×10^2 V/m, toward plate I

B. 4.00×10^2 V/m, toward plate II

C. 4.20×10^4 V/m, toward plate I

D. 4.20×10^4 V/m, toward plate II

- the direction of an $|\vec{E}|$ is the same as a "+" test charge would move if placed in the field... so from + → −

Use the following additional information to answer the next question.

The apparatus is then modified so that there is no electric field between plate I and plate II. The current flowing to the solenoids is adjusted so that the electrons are deflected in a circular path of radius 2.05 cm with a speed of 2.10×10^7 m/s.

$\vec{B}$ only F_m causes F_c

$F_m = F_c$

$qvB = \frac{mv^2}{R}$

$\vec{B} = \frac{mv}{qR}$

$= \frac{(9.11\times10^{-31})(2.1\times10^7)}{(1.6\times10^{-19})(.0205)}$

$= 5.93 \times 10^{-3}$ T

Numerical Response

2. The magnitude of the magnetic field between the coils, expressed in scientific notation, is $a.bc \times 10^{-d}$ T. The values of a, b, c, and d are 5, 8, 3, and 3.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

13. Atoms in the phosphorescent screen absorb the energy of the cathode ray particles. They re-emit this energy in the form of photons of energy 4.11×10^{-19} J. One of these photons has a wavelength, expressed in scientific notation, of

A. 1.61×10^{-15} m

B. 4.84×10^{-7} m

C. 2.07×10^{6} m

D. 6.20×10^{14} m

$E_{photon} = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{E} = \frac{(6.63\times10^{-34}\ J\cdot s)(3.00\times10^8\ m/s)}{4.11\times10^{-19}\ J}$

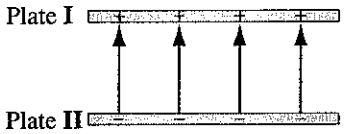
$= 4.84 \times 10^{-7}$ m

(visible light spectrum)

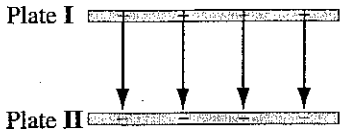
$|\vec{E}|$ field lines are drawn + → −

14. Which of the following diagrams shows the direction of the electric field between plate I and plate II?

A.

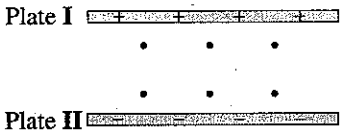


B.

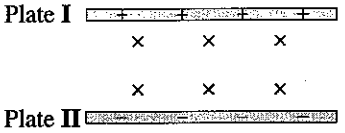


note uniform field (lines of force are evenly spaced)

C.



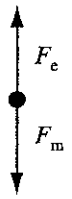
D.



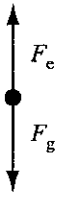
• Indicates an electric field oriented out of the page
× Indicates an electric field oriented into the page

15. Which of the following free-body diagrams shows the forces acting on an individual electron as it passes undeflected between plate I and plate II?

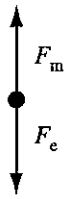
A.



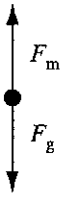
B.

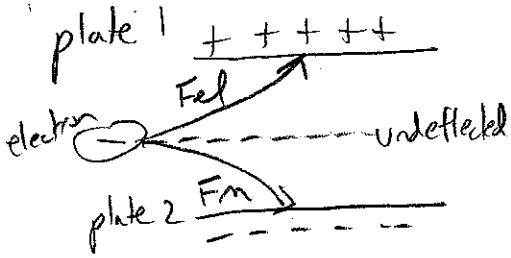


C.



D.





16. One of the reasons that Rutherford's planetary model of the atom has been modified is that observations of the atom do not support the theory of electrons orbiting the nucleus in a manner similar to planets orbiting a star. However, according to Maxwell's theory of electromagnetic radiation, such an orbiting electron should emit electromagnetic radiation because

- an electron moving in a circular path is constantly changing its direction and is therefore Δv (accelerating)

A. the electron is travelling at uniform speed

B. the electron is accelerating toward the nucleus

C. there is an electrostatic force of repulsion between the orbiting electrons

D. there is an alternating electromagnetic dipole as the electron switches sides of the nucleus

According to Maxwell an accelerating charge should emit emr.

Use the following information to answer the next question.

Louis de Broglie determined that the wavelength of a particle with mass and speed is given by the equation $\lambda = \frac{h}{mv}$. matter waves (particles can behave as waves)

17. If a proton and an electron have identical speeds, then the proton will have a

A. longer wavelength and a smaller momentum than those of the electron

B. shorter wavelength and a greater momentum than those of the electron

C. shorter wavelength and a smaller momentum than those of the electron

D. longer wavelength and a greater momentum than those of the electron

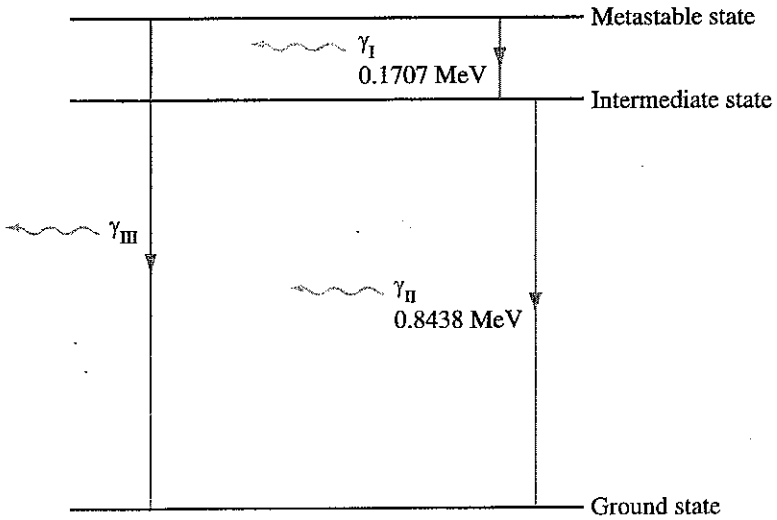
$\lambda = \frac{h}{mv}$

$\lambda > \frac{h}{p}$

$\lambda \propto \frac{1}{p}$ Since a proton has a larger mass and more momentum it should have a shorter λ

Use the following information to answer the next three questions.

Magnesium-27 is an isotope of magnesium that undergoes beta negative decay. The half-life of magnesium-27 is 9.45 min. The daughter nucleus of this decay is initially produced in a metastable, excited state. Three gamma photons may be emitted as the nucleus makes transitions from this excited state to the ground state. These transitions are shown in the diagram below.



18. The daughter nucleus produced by the beta negative decay of magnesium-27 is

A. $^{23}_{10}Ne$

B. $^{27}_{11}Na$

C. $^{27}_{13}Al$

D. $^{31}_{14}Ne$

$^{27}_{12}Mg \rightarrow {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu} + {}^{27}_{13}Al$

19. If a sample initially contains 15.0 g of magnesium-27, then the mass of magnesium-27 that remains after 20.8 min is

A. 3.26 g
B. 3.75 g
C. 6.82 g
D. 10.9 g

$N = N_0 \cdot .5^n$

$N = 15.0 \cdot .5^{2.201}$

$N = 3.26\ g$

$n = \frac{\text{time elapsed}}{t_{1/2}}$

$= \frac{20.8 \text{ minutes}}{9.45 \text{ minutes}}$

$= 2.201\ldots$

20. The longest wavelength of gamma radiation that can be emitted by the excited daughter nucleus is

A. 1.22×10^{-12} m
B. 1.47×10^{-12} m
C. 1.85×10^{-12} m
D. 7.28×10^{-12} m

$E = \frac{hc}{\lambda}$ since $E \propto \frac{1}{\lambda}$ the longest wavelength will correspond to the LOWEST ENERGY transition Y_I

$0.1707 \times 10^6 \text{ eV} = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{0.1707 \times 10^6 \text{ eV}}$

$\lambda = \frac{4.14 \times 10^{-15} \text{ eV} \cdot \text{s} \cdot 3.00 \times 10^8 \text{ m/s}}{0.1707 \times 10^6 \text{ eV}}$

$\lambda = 7.28 \times 10^{-12}\ m$

this is the wave

Use the following information to answer the next question.

Each of the following statements gives a characteristic of either a fusion reaction or a fission reaction.

1 A heavy nucleus is split into two or more lighter nuclei. fission
2 Two nuclei are combined into one. fusion
3 It is the dominant nuclear reaction on the sun. fusion
4 The products of the reaction are harmless. product ${}^{4}_{2}He + {}^{1}_{0}n$ -> fusion
5 The reaction produces radioactive isotopes. fission does this
6 Extremely high temperatures are needed to start the reaction. fusion

Numerical Response

3. The statements above that describe nuclear **fusion**, listed in ascending order, are _____, _____, _____, and _____.

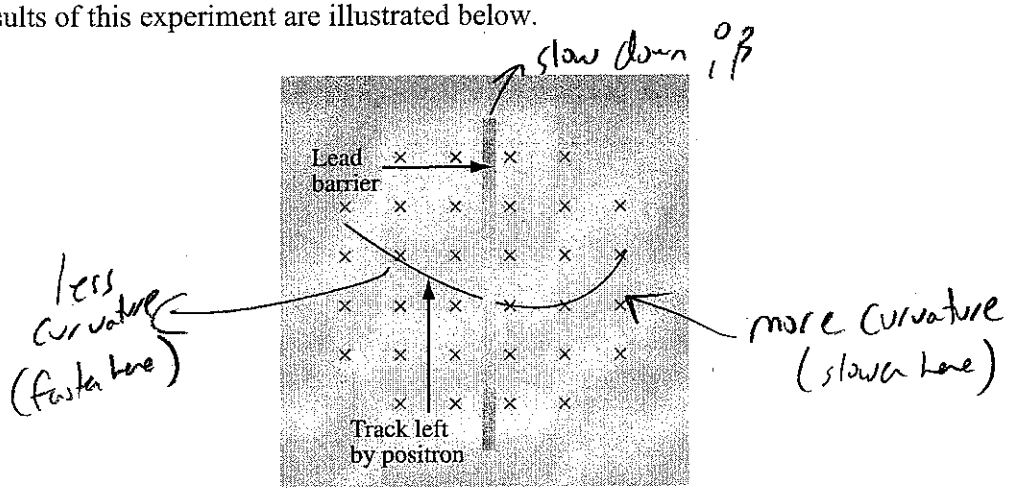
(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

1 2 4 6

Use the following information to answer the next question.

The first evidence of antimatter was a photograph of the track produced by a positron as it moved through a perpendicular magnetic field inside a cloud chamber.

An electron moving in one direction through a magnetic field in a cloud chamber leaves a track identical to that of a positron moving in the opposite direction. To prove that a track was made by a positron, scientists conducted an experiment: a thin lead barrier was placed across the path of the particle to slow the particle as it passed through the barrier, thereby revealing the particle's direction of travel. The results of this experiment are illustrated below.



× Represents a magnetic field directed into the page

21. The relative speed of the positron on either side of the barrier is determined by comparing the

A. length of the track on either side of the barrier
B. direction of the curvature on either side of the barrier
C. strength of the magnetic field on either side of the barrier
D. radius of the curvature of the path on either side of the barrier

A slower moving particle is deflected more than a faster moving particle (with the same mass).