Key

Example Diploma Examination Part B

1. *The risk of a motorist becoming fatally injured in a vehicle collision is reduced when an airbag or a seatbelt is used because the airbag or seatbelt* __**i**__ *change in momentum by* __**ii**__ *the stopping force the motorist experiences.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	achieves the same	decreasing
B.	achieves the same	increasing
C.	decreases the	decreasing
D.	increases the	increasing

Impulse = Δp

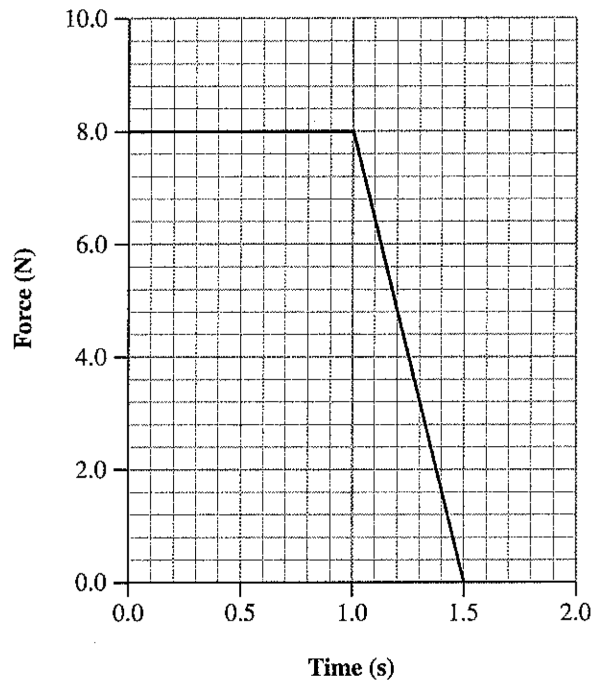
$F\Delta t = m\Delta v$

the airbag ↑ the time and ↓ Force during the time the momentum is brought to ∅.

Use the following information to answer the next two questions.

The initial speed of a remote-controlled toy car on a horizontal surface is 3.0 m/s. The car then experiences a force in the direction of its motion. A graph of this force as a function of time is given below. The mass of the car is 5.0 kg.

Force on Toy Car as a Function of Time



Two students analyze the motion of the car. One student looks at the first 1.0 s time interval. The other student looks at the complete 1.5 s time interval.

2. The speed of the toy car at the end of the 1.0 s time interval is

A. 1.4 m/s
B. 1.6 m/s
C. 4.6 m/s
D. 8.0 m/s

Impulse = Δp
area $(F \Delta t) = \Delta p$
$l \times w = m \Delta v$
$\frac{8.0 \times 1.0}{5} = \Delta v$
$1.6 \text{ m/s} + 3.0 \text{ m/s} (v_i) = 4.6 \text{ m/s}$

3. The magnitude of the impulse of the toy car during the 1.5 s time interval is

A. 10 kg·m/s
B. 12 kg·m/s
C. 24 kg·m/s
D. 40 kg·m/s

Impulse = area
$= \Delta + \square$
$= \frac{1}{2} bh + l \times w$
$= \left(\frac{1}{2} \cdot .5 \times 8\right) + (8.0 \times 1.0)$
$= 10 \text{ N}\cdot\text{s} \left(\text{kg}\cdot\frac{\text{m}}{\text{s}}\right)$

Use the following information to answer the next seven questions.

There are many different types of propulsion engines for satellites. One type of ion propulsion thrust chamber and the satellite to which it is attached are described below.

The cylindrical thrust chamber of the engine has a central spike. Electromagnets are used to produce a non-uniform magnetic field directed radially toward the spike. A virtual cathode consisting of trapped electrons is located at the rear of the thrust chamber. An electric field exists between the anode and the virtual cathode.

Positive xenon ions enter the thrust chamber at the anode and accelerate toward the virtual cathode, which results in thrust on the satellite. As the xenon ions pass through the virtual cathode, they pick up electrons and neutral xenon atoms fly out of the chamber.

Diagram I: Thrust Chamber in Engine

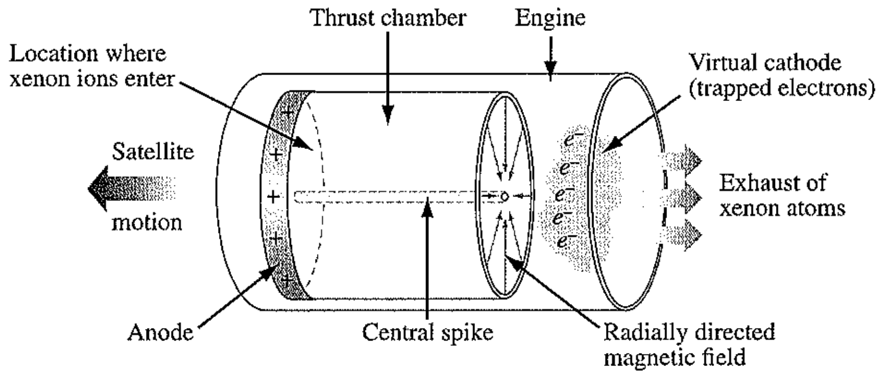
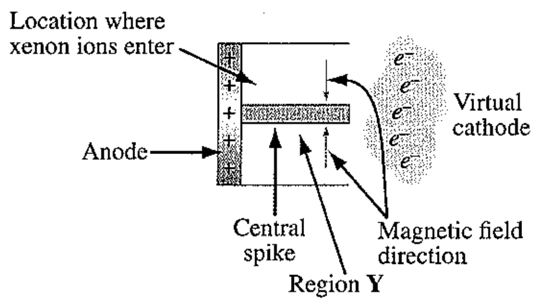


Diagram II: Cross Section of Thrust Chamber



Thrust Chamber Specifications

Magnetic field intensity at the location where the xenon ions enter	0.0200 T
Electric field intensity at the location where the xenon ions enter	1.00×10^{4} V/m
Mass of one xenon ion, Xe^{+}	2.19×10^{-25} kg
Exit speed of neutral xenon atom with respect to the thrust chamber	1.5×10^{4} m/s

4. In diagram II on the previous page, the direction of the **electric field** in region Y is

- **A.** to the right
- **B.** to the left
- **C.** into the page
- **D.** out of the page

from + → −

5. As the xenon ions, Xe^+, move through region Y, as labelled in diagram II on the previous page, they experience both electric and magnetic forces. The direction of the **magnetic force** that they experience is 3rd right hand rule

- **A.** into the page
- **B.** out of the page
- **C.** toward the top of the page
- **D.** toward the bottom of the page

↑ magnetic field direction in region Y

→ direction of ion movement

palm is ⊙

6. The xenon ions, Xe^+, enter the thrust chamber at a negligible speed. The minimum distance between the anode and the virtual cathode that is required to produce the exit speed is

- **A.** 1.2×10^{-16} m
- **B.** 1.0×10^{-6} m
- **C.** 1.5×10^{-2} m
- **D.** 1.4×10^{12} m

1) $F_{el} = q|E|$

$= (1.6\times10^{-19})(1.0\times10^{4})$

$= 1.6\times10^{-15}$ N

2) $a = \frac{F_{el}}{m} = \frac{1.6\times10^{-15}\text{ N}}{2.19\times10^{-25}\text{ kg}}$

$= 7.30\times10^{9}$ m/s²

3) $v_f^2 = v_i^2 + 2ad$

$(1.5\times10^{4})^2 = \emptyset + 2(7.3\times10^{9})d$

$d = 1.5\times10^{-2}$ m

Numerical Response

1. While in the thrust chamber, a xenon ion experiences an impulse, expressed in scientific notation, of $\boldsymbol{a.b} \times 10^{-\boldsymbol{cd}}$ kg·m/s. The values of $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, and $\boldsymbol{d}$ are ______, ______, ______, and ______.

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

impulse $= \Delta p$

$= m\Delta v$

$= (2.19\times10^{-25})(1.5\times10^{4}\text{ m/s})$

$= 3.285\times10^{-21}$ kg·m/s

$= 3.3\times10^{-21}$

$\boxed{3\ 3\ 2\ 1}$

Use the following additional information to answer the next question.

Xenon ions, m_{ion}, reach the virtual cathode with a speed of v_1. When a xenon ion collides with a stationary electron, m_e, in the virtual cathode, the xenon atom, m_{atom}, formed has a speed of v_2.

7. The relationship between v_2 and v_1 can be expressed as

conservation of momentum (linear)

A. $v_2 = \left(\dfrac{m_{\text{ion}} + m_e}{m_{\text{atom}}}\right) v_1$

$p_{\text{before}} = p_{\text{after}}$

B. $v_2 = \left(\dfrac{m_{\text{atom}}}{m_{\text{ion}} + m_e}\right) v_1$

$M_{\text{ion}} V_1 = M_{\text{atom}} V_2$

C. $v_2 = \left(\dfrac{m_{\text{ion}}}{m_{\text{atom}}}\right) v_1$

$\left(\dfrac{m_{\text{ion}}}{m_{\text{atom}}}\right) v_1 = v_2$

D. $v_2 = \left(\dfrac{m_{\text{atom}}}{m_{\text{ion}}}\right) v_1$

Use the following additional information to answer the next two questions.

Ion Propulsion Engine and Satellite Specifications

Average thrust applied by the engine to the satellite	0.200 N
Mass of satellite and propulsion system	2.5×10^3 kg
Speed of xenon atom exiting the thrust chamber	1.5×10^4 m/s
Mass of xenon atom	2.19×10^{-25} kg

8. The length of time, in hours, that this type of ion propulsion engine must be in operation in order to increase the speed of the satellite and propulsion system by 12.0 m/s is

A. 0.0240 h

B. 41.7 h

C. 250 h

D. 1.50×10^5 h

Impulse = Δp

$F \Delta t = m \Delta v$

$0.200 N \cdot \Delta t = (2.5 \times 10^3)(12)$

$\Delta t = \frac{1.5 \times 10^5 s}{3600 s/hr} = \underline{41.7 h}$

9. The number of xenon atoms that would have to be discharged as exhaust in order to increase the speed of the satellite and propulsion system described above by 1.00 m/s is

A. 5.1×10^{19} atoms

B. 7.8×10^{21} atoms

C. 1.6×10^{22} atoms

D. 7.6×10^{23} atoms

(reaction) satellite $\leftarrow$ atoms (action) $\rightarrow$

$p_{before} = p_{after}$

$0 = m_{sat} v_{sat} + m_{atom} v_{atom}$

$0 = (2500 \times 1.0) + m_{atom}(1.5 \times 10^4)$

$\frac{-2500 \text{ kg m/s}}{1.5 \times 10^4 \text{ m/s}} = m_{atom}(\text{total})$

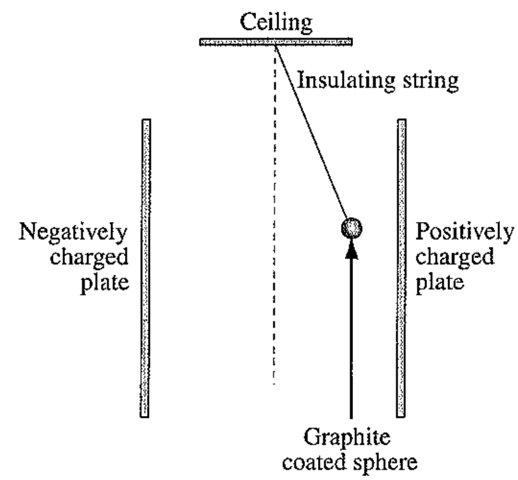
$\frac{.1\overline{6} \text{ kg}}{2.19 \times 10^{-25} \text{ kg/atom}} = m$

$7.6 \times 10^{23} \text{ atoms} = m$

Use the following information to answer the next four questions.

A negatively charged, graphite-coated sphere is suspended from the ceiling on an insulating string in the region between oppositely charged parallel plates, as illustrated below.

The plates are 20.0 cm apart and are maintained at an electrical potential difference of 3.1×10^2 V. The charged sphere experiences an electrical force of 8.4×10^{-7} N.



10. *One way to give the graphite-coated sphere a negative charge is to touch it with a ___i___ charged rod. This process is called charging by ___ii___.*

The statements above are completed by the information in row

Row	*i*	*ii*
A.	positively	induction
B.	positively	conduction
C.	negatively	induction
D.	negatively	conduction

Charging by conduction (contact) result in objects acquiring the same type of charge.

eg

contact

both are negative.

Numerical Response

2. The charge on the graphite-coated sphere, expressed in scientific notation, is $a.b \times 10^{-cd}$ C. The values of a, b, c, and d are __5__, __4__, __1__, and __0__.

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

① $|E| = \frac{V}{d} = \frac{310\,V}{0.20\,m} = 1550\,V/m$

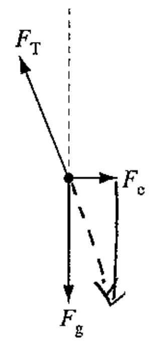
② $|E| = \frac{F_e}{q}$

$1550 = \frac{8.4 \times 10^{-7}}{q}$

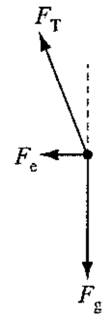
$q = 5.4 \times 10^{-10}\,C$

11. Which of the following scale diagrams is the free-body diagram for the negatively charged sphere?

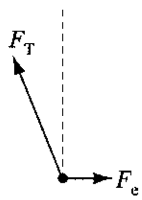
A.



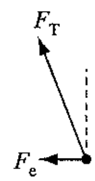
B.



C.



D.



Use the following additional information to answer the next question.

> The charged plates are now removed. The positively charged plate is replaced by the north pole of a strong magnet and the negatively charged plate is replaced by the south pole of a strong magnet. The system is allowed to reach equilibrium.

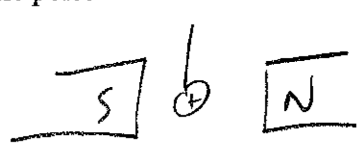
12. As a result of the magnetic field, the negatively charged, graphite-coated sphere will

A. swing back and forth between the magnetic poles

B. be deflected toward the magnetic north pole

C. be deflected toward the magnetic south pole

D. hang midway between the magnetic poles



a charge must be moving in order to experience a F_m.

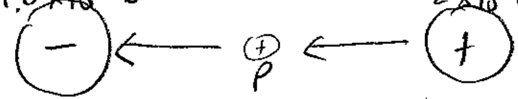
Use the following information to answer the next question. #(member lines of force are drawn away from + and toward −

> Two small metal spheres are fixed to insulated stands and given static charges of -4.00×10^{-6} C and $+2.00 \times 10^{-6}$ C, respectively. The spheres are then placed 0.500 m apart. Point *P* is halfway between the charged spheres.

13. At point *P*, the magnitude of the electric field caused by the two charged spheres is

A. 8.63×10^{5} N/C
B. 2.88×10^{5} N/C
C. 2.16×10^{5} N/C
D. 7.19×10^{4} N/C

4.0×10^{-6} 2×10^{-6}



$|E|=\frac{kq}{r^2}$

$=\frac{\cancel{(8.99\times10^9)(4\times10^{-6})}}{(0.25)^2}=575360\ N/C$

$|E|_2=\frac{8.99\times10^9\cdot2\times10^{-6}}{(.25)^2}$

$=287680\ N/C$

$|\vec{E}_p|=|E|_1+|E|_2$

$=575360+287680$

$=8.63\times10^5\ N/C$

Use the following information to answer the next question.

> In all electronic camera flashes, there is a capacitor, which is a device that allows large quantities of charge to be stored. The charge accumulates and is then released very quickly.
>
> The electrical energy stored in a capacitor is given by $E = \frac{1}{2}CV^2$,
>
> where V = potential difference across the capacitor
> and C = the capacitance of the capacitor in farads

14. Which of the following combinations of coulombs, joules, and/or volts is equivalent to a farad?

A. $\frac{C^2}{J}$

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

C. $\frac{J}{C^2}$

D. $\frac{C^2}{V}$

$V=\frac{\Delta E}{q}$

$V=\frac{J}{C}$

$E=\frac{1}{2}CV^2$

$\frac{2E}{V^2}=C$

$\frac{J}{V^2}=C$

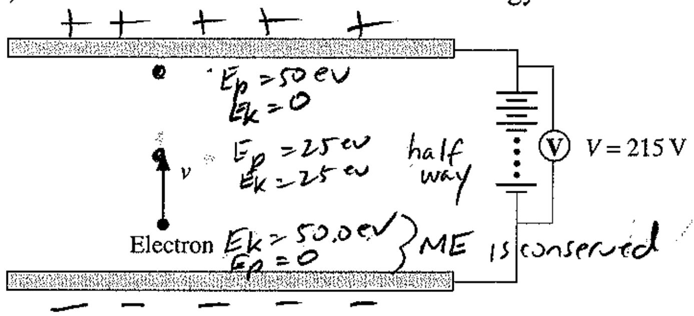
$\frac{J}{\frac{J^2}{C^2}}=C$

$\cancel{J}\times\frac{C^2}{J^{\cancel{2}}}=C$

$\frac{C^2}{J}=C$

Use the following information to answer the next question.

An electron is initially at rest at the negatively charged plate. At the instant illustrated below, the electron has 50.0 eV of kinetic energy.



Numerical Response

3. At any point along the path followed by the electron, the sum of the kinetic energy of the electron and its electrical potential energy, in units of electronvolts, is 50.0 eV.

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

Use the following information to answer the next question.

An electron is fired into an electric field between oppositely charged plates, as shown below.

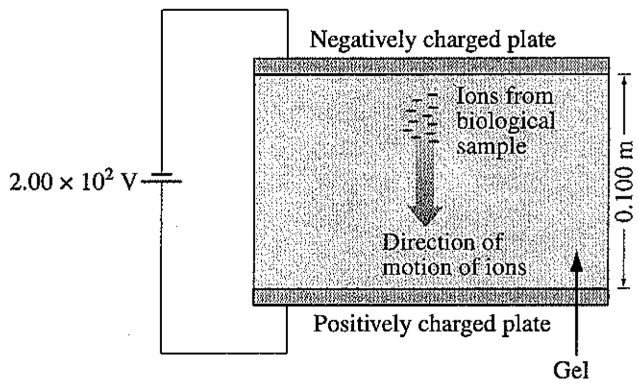
15. The path taken by the electron while inside the electric field resembles the path taken by

A. a rock thrown horizontally from a high cliff projectile motion → uniform, accel by F_{el}
B. an alpha particle entering a magnetic field perpendicularly
C. a hammer tied to a string and whirled above a person's head
D. a charged oil drop released in the region between oppositely charged plates

Use the following information to answer the next four questions.

One of the methods used to link a person to a crime scene is DNA fingerprinting. DNA fingerprints are as unique as the patterns on fingertips. The laboratory procedure used to produce a DNA fingerprint is called gel electrophoresis.

The apparatus used in gel electrophoresis consists of two parallel plates that have an electrical potential difference between them. A layer of thick gel is placed in the region between the parallel plates such that the electric field direction is parallel to and inside the layer. In one step in creating a DNA fingerprint, molecules from a sample are given an electrical charge turning them into ions. These ions are placed at one end of the gel layer next to the negatively charged plate. As a result of the electrostatic repulsion, the electrical force does work moving the ions through the thick gel. Ions with a smaller size or a larger charge move farther through the gel layer.



16. When the molecules in the biological sample are turned into ions,

A. protons are added ✗
B. electrons are added
C. protons are removed
D. electrons are removed ✗

protons cannot be added or removed (unless the change is nuclear)

since ions are − they must have gained electrons

17. As an ion moves toward the positively charged plate, the magnitude of the electrical force experienced by the ion

A. increases as the distance decreases
B. is constant as the distance decreases
C. increases as the square of the distance decreases
D. decreases as the square of the distance decreases

In a uniform $|\vec{E}|$ (between opposite charged plates) the F_{el} is constant anywhere in the field.

Numerical Response

4. The magnitude of the electric field between the plates, expressed in scientific notation, is $a.bc \times 10^d$ N/C. The values of a, b, c, and d are 2, 0, 0, and 3.

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

$$|\vec{E}| = \frac{V}{d} = \frac{200\,V}{.10\,m} = 2.00 \times 10^{3}\ \frac{V}{m}$$

18. In forming a DNA fingerprint, a particular ion has been moved 3.00 cm through the gel. The magnitude of the charge of the ion is $2e$. The work done by the electrostatic force to move the ion this distance is

A. 1.20×10^2 eV
B. 1.20×10^2 J
C. 4.00×10^2 eV
D. 4.00×10^2 J

$W = F_{el}d$

$W = q|\vec{E}| \cdot d$

$W = (3.20 \times 10^{-19} \cdot 2000) \times 0.03\,m$

$W = 1.92 \times 10^{-17}\,\cancel{J} \times \frac{1\,eV}{1.60 \times 10^{-19}\,\cancel{J}}$

$W = 120\,eV$ ✓

Use the following information to answer the next question.

Electrons can produce gravitational, electric, and magnetic fields as a result of the following properties.

1 Charge
2 Mass → gravitational field
3 Speed

– a stationary charge creates an $|\vec{E}|$
– a moving charge creates a $|\vec{B}|$

Numerical Response

5. Match electron properties as listed above with the field that they produce as given below. You may use a number more than once. There is more than one correct answer.

Property:	2	1	1 and 3	
Field:	**Gravitational Field**	**Constant Electric Field**	**Magnetic Field**	

2 1 3 1

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

19. An electromagnetic wave is created by

A. a constant electromagnet
B. a changing field of any kind
C. a magnet in an electric field
D. an accelerating electric charge

this was proposed by MAXWELL
see page. 185 in your workbook.

Use the following information to answer the next question.

Several Methods Used to Estimate the Speed of Light

1. Observe the time delay for an eclipse of a moon of Jupiter.
2. Observe the time delay between uncovering a light on one mountain and having an observer on another mountain react to the sign and uncover a second light.
3. Observe the interference pattern produced by a single source that emits light that travels slightly different but precisely measured distances.

Numerical Response

6. When the methods given above are ordered from the one that produced the least accurate estimate to the one that produced the most accurate estimate, the order is

________, ________, ________.

least accurate **most accurate**

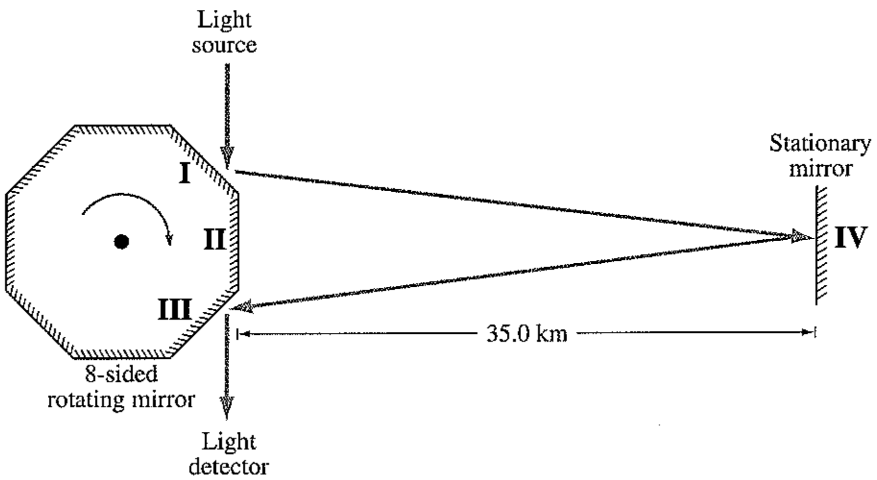
(Record all **three digits** of your answer in the numerical-response section on the answer sheet.)

2 1 3

see page 194 → 201 in workbook.

Use the following information to answer the next question.

One accurate method to measure the speed of light is illustrated below. When the 8-sided mirror is stationary, light from the source reflects from surface I, travels to the stationary mirror, reflects from surface IV, travels back to the 8-sided mirror, reflects from surface III, and is incident on the detector.



As the 8-sided mirror begins to rotate, the light does not follow the path illustrated. Eventually, as the frequency of rotation of the mirror increases, a series of light pulses follow the path illustrated.

20. The minimum frequency at which the 8-sided mirror must rotate so that a pulse of light follows the path illustrated is

A. 5.36×10^2 Hz
B. 1.07×10^3 Hz
C. 4.29×10^3 Hz
D. 3.43×10^4 Hz

1 Hz = 1 RPS

(1) find time for light to travel 70 km

$$v = \frac{d}{t}$$

$$3.00 \times 10^8 = \frac{70000 m}{t}$$

$$t = 2.\overline{3} \times 10^{-4} s$$

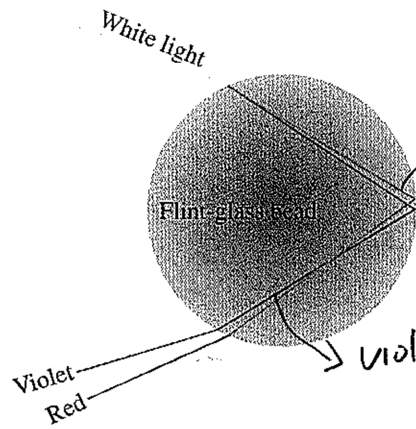
(2) Rotating mirror has made $\frac{1}{8}$ R in this time

$$\frac{\frac{1}{8} R}{2.3 \times 10^{-4} s} = \frac{? R}{1 s}$$

536 RPS

Use the following information to answer the next question.

When white light from the sun strikes a flint-glass bead, the white light is separated into its component colours, two of which are illustrated in the diagram below.



(beads) red refracts less (↓n)

refractive index (n)

violet refracts more (↑n)

this is called dispersion

21. Which of the following statements contains a valid prediction of the relative indices of refraction for red and violet light and a justification of that predication?

A. The index of refraction of red light in flint glass is greater than that of violet light because red light refracts more inside the flint-glass bead.

B. The index of refraction of red light in flint glass is less than that of violet light because red light refracts less inside the flint-glass bead.

C. The index of refraction of violet light in flint glass is greater than that of red light because violet light reflects more inside the flint-glass bead.

D. The index of refraction of violet light in flint glass is less than that of red light because red light reflects less inside the flint-glass bead.

Numerical Response

7. On a particular day, the index of refraction of a 5 MHz radio signal in Earth's atmosphere is 1.81. The critical angle for this radio signal is __________°.

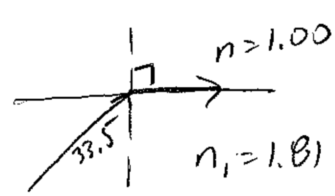
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

- a critical angle produces a refracted angle of 90°.
- a critical angle always occurs in medium 1 (more dense)

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

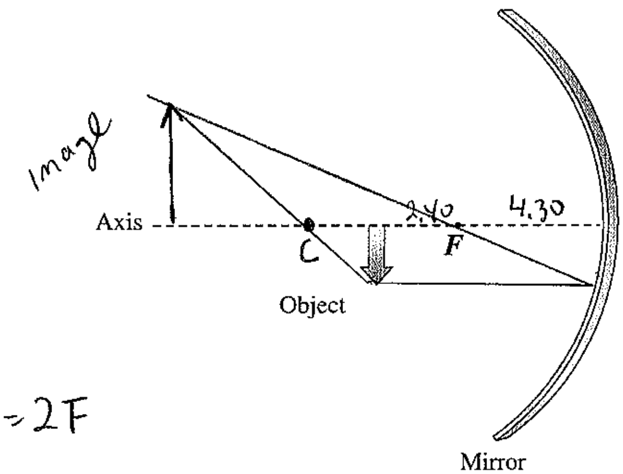
$$\frac{\sin\theta_1}{\sin 90} = \frac{1.00}{1.81}$$

$\theta_1 = 33.5°$



Use the following information to answer the next question.

A concave mirror, its central axis, and an object are shown in the diagram below.



C=2F

The distance from the object to the focal point is 2.40 cm and the focal length of the mirror is 4.30 cm.

22. The distance from the image to the mirror is

A. 0.0833 cm
B. 0.184 cm
C. 5.43 cm
D. 12.0 cm

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{4.3} = \frac{1}{6.7} + \frac{1}{d_i}$$

$$\frac{1}{d_i} = 12.0\text{cm}$$

answer is C ?

I drew a ray diagram which shows that C can't be correct. The right answer should be D.

Use the following information to answer the next four questions.

A student follows three procedures to study the properties of laser light. She uses a laser that emits monochromatic light that has a wavelength of 634 nm.

	Procedure	Observation
I	The student first shines the laser light through a crystal that has an index of refraction of 1.53.	The path of the refracted ray is recorded.
II	The student shines the laser light through a diffraction grating that has 5.00×10^5 lines/m.	An interference pattern is projected onto a screen.
III	The student shines the laser light upon a photovoltaic cell that is connected to an ammeter.	No electrical current is measured.

23. The energy of one photon emitted by the laser is

A. 4.20×10^{-40} J
B. 4.20×10^{-31} J
C. 3.14×10^{-28} J
D. 3.14×10^{-19} J

$E = \frac{hc}{\lambda}$

$E = \frac{6.63 \times 10^{-34} \cdot 3.00 \times 10^{8}}{634 \times 10^{-9} m}$

$E = 3.14 \times 10^{-19} J$

24. *In procedure I, the wavelength of the laser light in the crystal is __i__. The speed of the laser light in the crystal is __ii__ than its speed in air.*

The statements above are completed by the information in row refraction - Snell's law

Row	*i*	*ii*
A.	4.14×10^{-7} m	less
B.	4.14×10^{-7} m	greater
C.	9.70×10^{-7} m	less
D.	9.70×10^{-7} m	greater

$\frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$

1 - crystal
2 - air

$\frac{6.34 \times 10^{-7}}{\lambda_2} = \frac{1.53}{1.00}$

$\lambda = 4.14 \times 10^{-7} m$

- since crystal is more dense than air, it would slow light down remember d is inverse of $\frac{\text{lines}}{m}$

$x = d \sin\theta$

$\frac{1}{n}$

$6.34 \times 10^{-7} = \frac{1}{5.00 \times 10^{5}} \cdot \sin\theta$

$\theta = 18.5°$

Numerical Response

8. In procedure II, the angle between the central maximum and the first bright spot of the interference pattern is __________°.

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

25. *In order to produce an electrical current in procedure III, the student must use electromagnetic radiation that has a __i__ wavelength or a photovoltaic plate that has a __ii__ work function than those she actually used in procedure III.*

The statement above is completed by the information in row

photoelectric effect

- $E_{light} \propto \frac{1}{\lambda}$ so shorter λ's are higher energy.
- a lower work function means an e^- is ejected requiring less energy.

Row	*i*	*ii*
A.	shorter	larger
B.	longer	larger
C.	shorter	smaller
D.	longer	smaller

26. Which of the following lists has selected regions of the electromagnetic spectrum arranged in order of increasing photon energy?

A. Radio, microwaves, X-rays, visible
B. Infrared, ultraviolet, X-rays, gamma
C. Gamma, visible, infrared, microwaves
D. Microwaves, ultraviolet, visible, infrared

Radio MW IR visible UV X-ray gamma

$\longrightarrow$ ↑f and ↑Energy

$\longleftarrow$ ↑wavelength.

27. A photocathode that has a threshold frequency of 5.6×10^{14} Hz is illuminated with light that has a frequency of 8.2×10^{14} Hz. The maximum kinetic energy of the ejected photoelectrons is

A. 1.7×10^{-19} J
B. 3.7×10^{-19} J
C. 5.4×10^{-19} J
D. 9.1×10^{-19} J

$E_{photon} = E_{k\,electron} + W$ (cons. of energy)

$hf = E_{k\,electron} + hf_0$

$(6.63 \times 10^{-34} \cdot 8.2 \times 10^{14}) = E_{k\,electron} + (6.63 \times 10^{-34} \cdot 5.6 \times 10^{14})$

$5.4366 \times 10^{-19}\text{ J} = E_k + 3.7128 \times 10^{-19}\text{ J}$

$1.7 \times 10^{-19}\text{ J} = E_k$

28. The explanation of the Compton effect requires the

A. wave nature of light
B. particle nature of light
C. probabilistic nature of quantum physics
D. ejection of electrons from a metal surface

photon momentum - momentum is a property associated with particles
$E=pc$; $p=\frac{h}{\lambda}$; $p=\frac{hf}{c}$

29. One immediate result of the discovery of cathode ray particles was that the theory of the atom was revised to a theory that hypothesized that

A. an atom is an indivisible sphere
B. electrons exist in probability clouds
C. an atom is mostly made up of empty space
D. an atom contains negatively charged particles

see the Thomson $\frac{q}{m}$ expt on pages 183/184

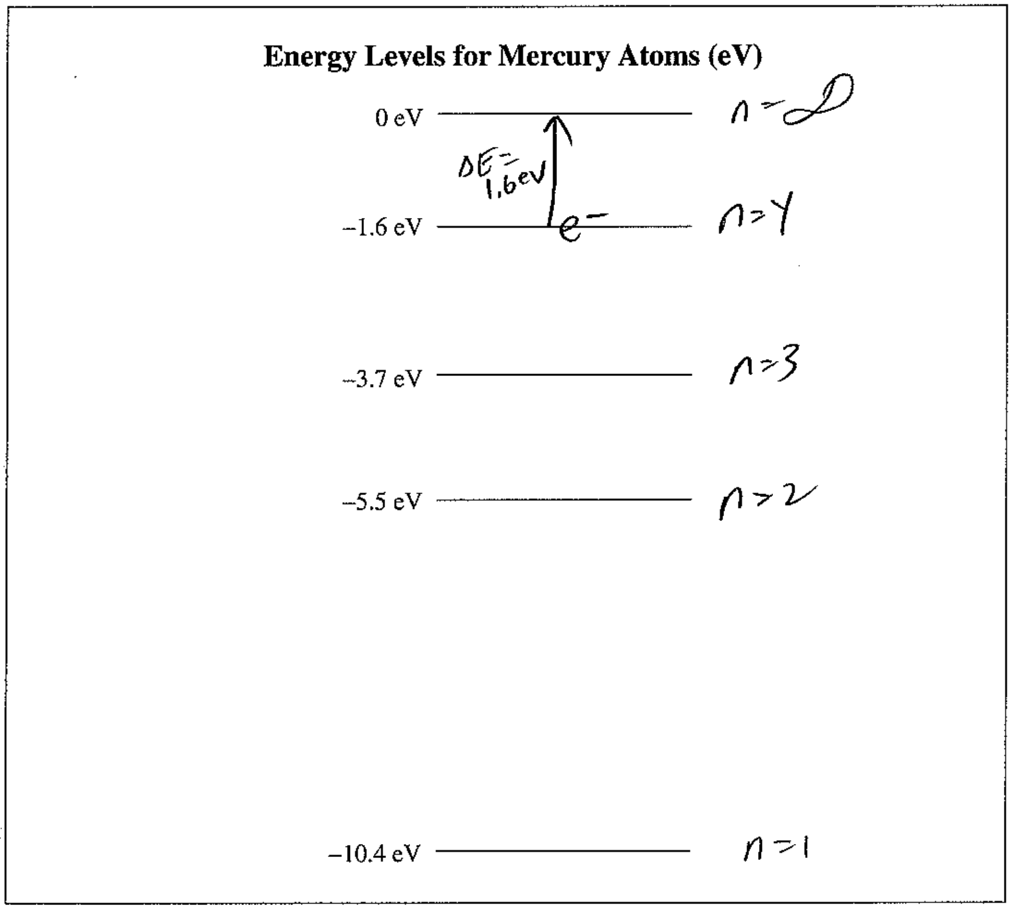
30. *The analysis of the observations from the Rutherford alpha particle scattering experiment lead to a model of the atom in which the __i__ is on the order of 10^{-10} m in diameter, the __ii__ is on the order of 10^{-15} m in diameter, and the majority of the __iii__ of the atom is in the nucleus.*

The statement above is completed by the information in row

Row	*i*	*ii*	*iii*
A.	atom	nucleus	charge
B.	nucleus	atom	charge
C.	atom	nucleus	mass
D.	nucleus	atom	mass

Rutherford's alpha scattering experiment!

Use the following information to answer the next question.



31. If an electron is in the −1.6 eV energy level, the minimum frequency of a photon that would ionize the atom is

A. 3.9×10^{14} Hz
B. 2.1×10^{15} Hz
C. 2.4×10^{33} Hz
D. 1.3×10^{34} Hz

$$\Delta E = E_{ionize} - E_4$$
$$\Delta E = 0 - (-1.6\ \text{eV})$$
$$\Delta E = 1.6\ \text{eV required}$$

$$E = hf$$
$$\frac{1.6\ \text{eV}}{4.14 \times 10^{-15}\ \text{eV}\cdot\text{s}} = f$$
$$3.86 \times 10^{14}\ \text{Hz} = f$$

wave property!

32. For which of the following explanations did the diffraction of high-speed electrons provide experimental support?

using crystals as diffraction grating.

A. Bohr's explanation of line spectra

B. Compton's explanation of the Compton effect

C. Einstein's explanation of the photoelectric effect

D. De Broglie's explanation of wave nature of matter

Use the following information to answer the next two questions.

Cobalt-60 is a common radiation source used in cancer treatment. The half-life of cobalt-60 is 5.2 years. A cobalt-60 nucleus decays by emitting a beta negative particle and a gamma photon.

33. Which of the following equations describes the decay of cobalt-60?

A. ${}^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{28}\mathrm{Ni} + {}^{0}_{-1}\beta + \gamma + \nu$

remember.
cons of nucleons and charge.

B. ${}^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{28}\mathrm{Ni} + {}^{0}_{-1}\beta + \gamma + \bar{\nu}$

C. ${}^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{26}\mathrm{Fe} + {}^{0}_{+1}\beta + \gamma + \nu$

D. ${}^{60}_{27}\mathrm{Co} \rightarrow {}^{60}_{26}\mathrm{Fe} + {}^{0}_{+1}\beta + \gamma + \bar{\nu}$

Numerical Response

9. The percentage of cobalt-60 remaining after 15.6 years is 12.5 %.

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

$N = N_0 \cdot .5^n$

this is a %

$\frac{N}{N_0} = .5^n$

$.125 = .5^3$

$n = \frac{\text{time}}{t_{1/2}} = \frac{15.6}{5.2} = 3$

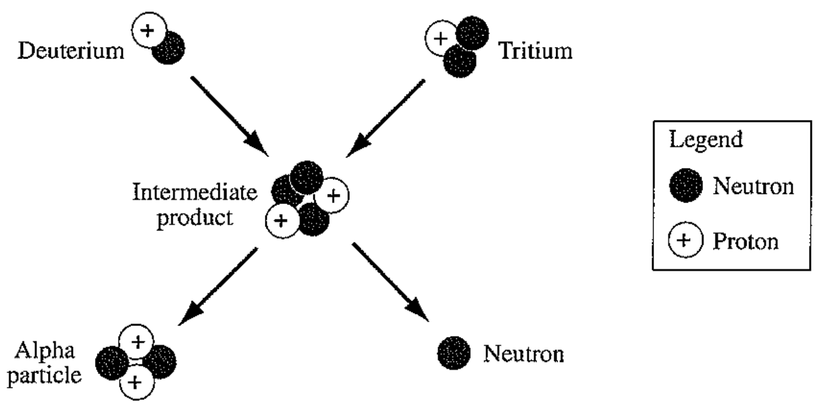
12.5% remains

Use the following information to answer the next six questions.

One Solar Nuclear Fusion Reaction Equation

$${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n + \text{Energy}$$

Representation of Nuclei Involved in This Fusion Reaction



One way to harness this energy on Earth is to use a nuclear fusion reactor. One of the problems in terrestrial fusion reactors is the very high energy required to overcome the electrostatic repulsive force between the deuterium ions and the tritium ions.

A particular reactor design uses magnetic fields in a process called magnetic confinement to keep the ions inside the reactor. However, neutrons escape magnetic confinement. These neutrons are captured by a shield called a lithium blanket.

34. Energy is released in this nuclear fusion reaction because the

A. free neutron has a high energy

B. number of protons remains the same

C. number of nucleons remains the same

D. mass of the alpha particle and neutron is less than the mass of the intermediate product

mass defect → converted to Energy.

$F_e = \frac{k q_1 q_2}{r^2}$ $23.3\,N = \frac{(8.99 \times 10^{9})(1.6 \times 10^{-19})^2}{r^2}$

$r = 3.14 \times 10^{-15}$ m

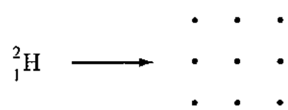
Numerical Response

10. At a particular instant, the electrostatic force that the deuterium ion exerts on the tritium ion is 23.3 N. The distance between the centres of the two ions, expressed in scientific notation, is __________ $\times 10^{-w}$ m.

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

Use the following additional information to answer the next question.

A positively charged deuterium ion enters a magnetic field directed out of the page, as shown below.



• Represents a magnetic field directed out of the page

35. The direction of the magnetic deflecting force that acts on the positively charged deuterium ion as it just enters the magnetic field is

- **A.** into the page
- **B.** out of the page
- **C.** toward the top of the page
- **D.** toward the bottom of the page

3rd right hand rule

fingers (out of page)

thumb →

palm - toward bottom of page.

only moving charges are deflected by $\vec{B}$.

36. The neutron produced in the fusion reaction escapes the magnetic confinement because

A. neutral particles are not deflected by magnetic fields

B. the neutron is moving so fast that it escapes the magnetic field

C. the energy produced in the nuclear reaction is enough to cause the neutron to escape

D. conservation of momentum requires that the neutron has to be pushed in the opposite direction to that of the helium produced

37. *As a particular neutron travelling at 5.21×10^6 m/s hits the lithium blanket and stops, it experiences an impulse of __i__, and the neutron–lithium collision is classified as __ii__.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	-8.70×10^{-21} N·s	elastic
B.	-8.70×10^{-21} N·s	inelastic
C.	-2.27×10^{-14} J	elastic
D.	-2.27×10^{-14} J	inelastic

stick (E_k not conserved)

$$\text{Impulse} = \Delta p = m\Delta v = m(v_f - v_i) = (1.67\times10^{-27})(0 - 5.21\times10^{6}) = -8.70\times10^{-21}\ \text{N·s}$$

38. Which of the following equations **most likely** describes a neutron–lithium collision?

A. ${}^{1}_{0}\text{n} + {}^{7}_{3}\text{Li} \rightarrow {}^{8}_{3}\text{Li}$

B. ${}^{1}_{0}\text{n} + {}^{4}_{3}\text{Li} \rightarrow {}^{5}_{3}\text{Li}$

C. ${}^{0}_{1}\text{n} + {}^{7}_{3}\text{Li} \rightarrow {}^{7}_{4}\text{Be}$

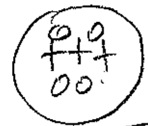
D. ${}^{1}_{1}\text{n} + {}^{4}_{3}\text{Li} \rightarrow {}^{5}_{4}\text{Be}$

39. To study sub-nuclear structure, high-energy particle accelerators are required because

nucleus.

A. plasma exists at high energy

B. antimatter exists at high energy



C. of the strength of the electrostatic force

D. of the strength of the strong nuclear force

→ Fel

→ strong nuclear.

40. Which of the following decay equations describes beta positive decay?

positron (positive electron) antimatter

A. $udd \rightarrow uud + e^{-} + \overline{\nu}$

B. $udd \rightarrow uud + e^{+} + \overline{\nu}$

proton → neutron

C. $uud \rightarrow udd + e^{-} + \nu$

D. $uud \rightarrow udd + e^{+} + \nu$

$^{1}_{1}p \rightarrow {}^{1}_{0}n + {}^{1}_{0}\beta + v$

$uud \rightarrow udd + e^{+} + v$

$\frac{2}{3}\ \frac{2}{3}\ \frac{-1}{3} \rightarrow \frac{2}{3}\ \frac{-1}{3}\ \frac{-1}{3}$