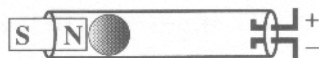


Physics 30 1996 June

Use the following information to answer the next five questions.

Deployment of Air Bags

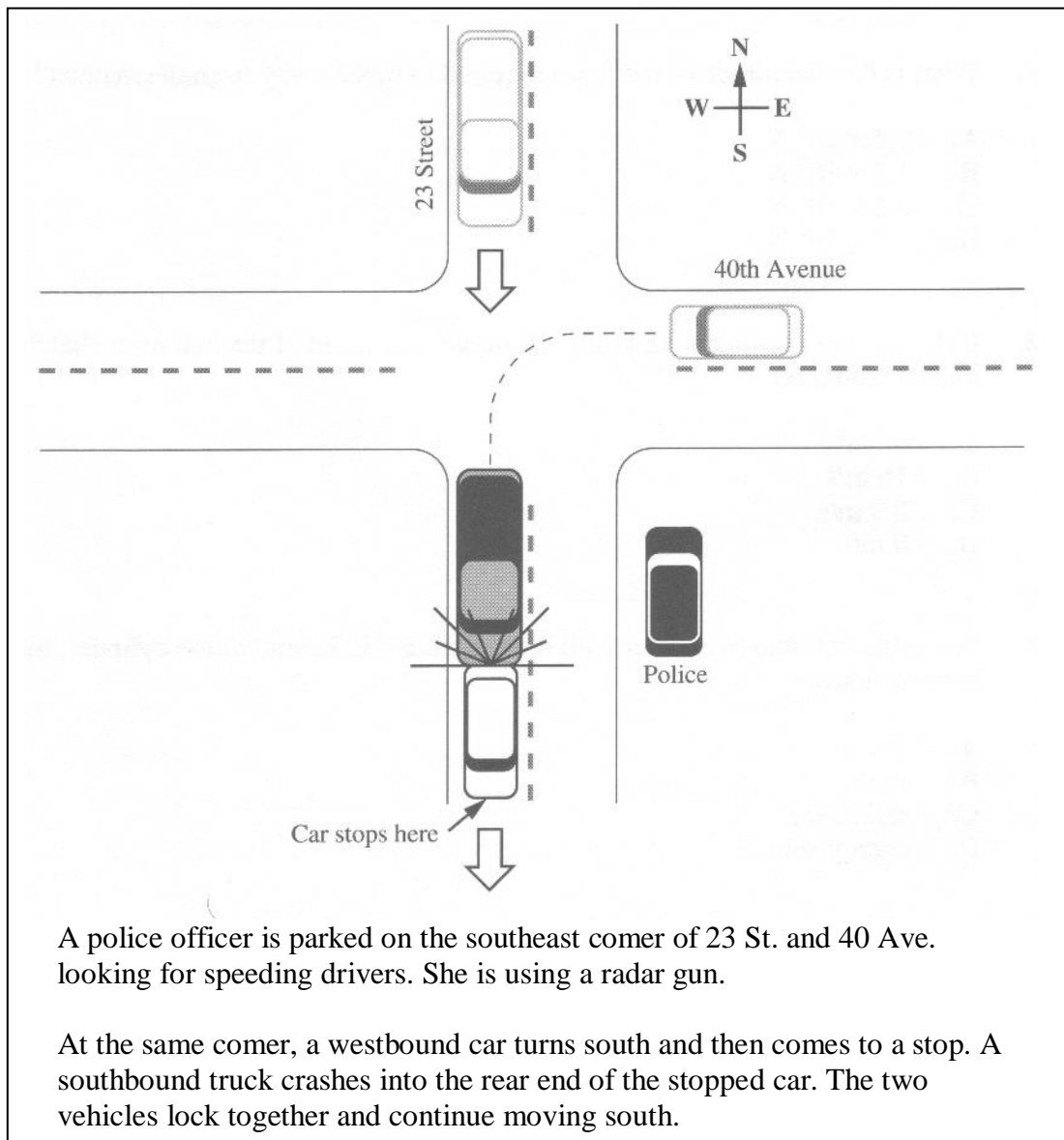


Air bags are designed to deploy when a car, moving at a minimum speed of 18 km/h, comes to a crashing stop. The impact sensor, also moving at 18 km/h, consists of a small steel ball of 0.050 kg, which is held in position by a magnet, as shown above. On impact, the ball breaks free in 1.00×10^{-3} s and slides within a cylinder. The ball makes contact with two electrodes at the end of the cylinder, thus activating the air bag.

- What is the magnitude of the force required to break away from the magnet?
 - 2.5×10^5 N
 - 1.3×10^5 N
 - 2.5×10^2 N
 - 1.3×10^2 N
- If the car was moving at 18 km/h, the maximum speed of the ball immediately after impact would be
 - 62 m/s
 - 18 m/s
 - 5.0 m/s
 - 0 m/s
- When the ball makes contact with the electrodes at the end of the cylinder, the ball behaves like a
 - circuit
 - switch
 - resistance
 - energy source

4. If the car was initially moving at 18 km/h, the driver had a mass of 70 kg, and the air bag stopped him in 0.10 s, the magnitude of the force acting on the driver during the deceleration would be
- A. $1.3 \times 10^4 \text{ N}$
 - B. $3.5 \times 10^3 \text{ N}$
 - C. $1.3 \times 10^3 \text{ N}$
 - D. $3.5 \times 10^2 \text{ N}$
5. The entire process, from impact to air bag inflation, takes less than $3.0 \times 10^{-3} \text{ s}$. During this same time, how far forward would a passenger who was not wearing a seat belt move?
- A. $1.5 \times 10^{-2} \text{ m}$
 - B. $1.8 \times 10^{-2} \text{ m}$
 - C. 5.0 m
 - D. 0 m

Use the following information to answer the next six questions.



Numerical Response

1. If the radar gun uses EMR that has a period of 4.20×10^{-10} s, the wavelength of the emitted wave is $b \times 10^{-w}$ m. The value of b is _____.
- (Record your **three-digit answer** in the numerical-response section on the answer sheet.)
6. The radar gun uses EMR in the microwave range. This type of EMR is generated by
 - A. a continuous DC current
 - B. an oscillating current in a solid-state device
 - C. a rapid deceleration of high energy electrons
 - D. an electron making a jump to a higher energy level

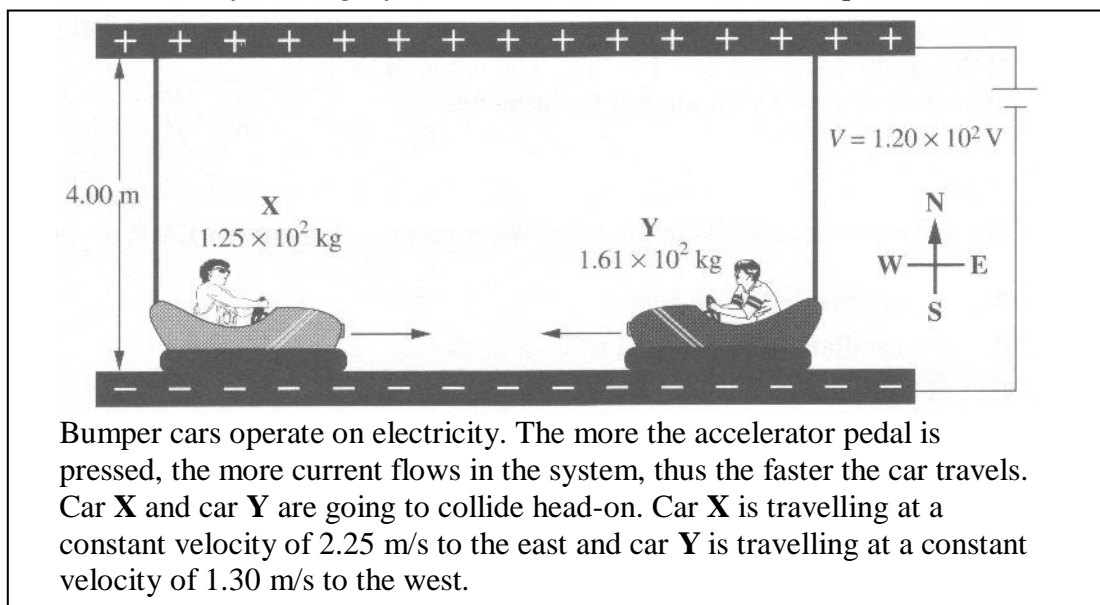
7. After witnessing the accident, the police officer uses a radio to call an emergency response team. The team is located 18.5 km from the accident when it receives the officer's direct transmission. The time it takes for the signal to travel to the team is
- A. $6.17 \times 10^{-8} \text{ s}$
 - B. $1.62 \times 10^{-7} \text{ s}$
 - C. $6.17 \times 10^{-5} \text{ s}$
 - D. $1.62 \times 10^{-4} \text{ s}$
8. The truck is equipped with a driver's-side air bag that was activated during the collision with the car. The main purpose of an air bag system is to
- A. shorten the stopping time of the driver's head and upper body as they move forward
 - B. act as a cushion and shield for glass and flying debris
 - C. lengthen the stopping time of the driver's head and upper body as they move forward
 - D. prevent the steering wheel from collapsing

Numerical Response

2. The car has a mass of 1850 kg. The truck was travelling at 65.1 km/h just before impact. After the car and truck locked together, they travelled at 26.2 km/h. The mass of the truck, expressed in scientific notation, is $b \times 10^w$ kg. The value of b is _____.

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

Use the following information to answer the next three questions.

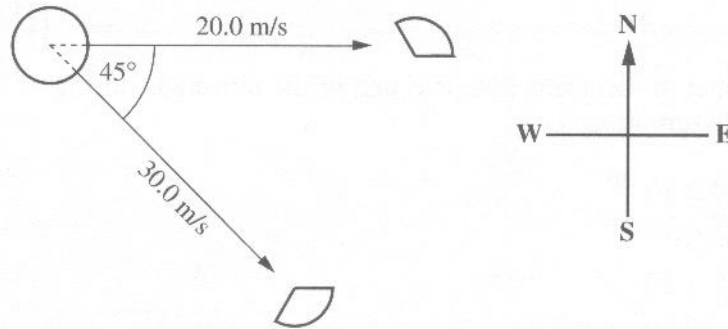


Numerical Response

3. The total mechanical energy of the bumper cars described, expressed in scientific notation, is $b \times 10^w \text{ J}$. The value of b is _____.
- (Record your **three-digit answer** in the numerical-response section on the answer sheet.)
9. If after the collision car Y is travelling at 0.526 m/s to the east, the velocity of car X immediately after impact would be
 - A. $1.02 \times 10^{-1} \text{ m/s}$ to the west
 - B. 3.25 m/s to the east
 - C. 4.60 m/s to the east
 - D. $1.02 \times 10^1 \text{ m/s}$ to the west
 10. The electric field between the top and bottom grids of the system is
 - A. 30.0 N/C up
 - B. 30.0 N/C down
 - C. 480 N/C up
 - D. 480 N/C down

Use the following information to answer the next two questions.

A stationary bomb exploded in a street in the centre of a city. The three pieces of debris from the bomb, each of approximately the same mass, flew off horizontally in different directions. Analysis revealed that one piece moved east at 20.0 m/s, and a second piece moved southeast at 30.0 m/s.



11. The third piece of debris was difficult to locate. Where should investigators look for the third piece?
- A. 27° W of N
 - B. 27° N of W
 - C. 22.5° S of W
 - D. 22.5° N of E

Numerical Response

4. The speed of the third piece, expressed in scientific notation, is $b \times 10^w$ m/s. The value of b is _____.

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

Use the following information to answer the next four questions.

A solar-powered battery maintainer is used to recharge batteries in automobiles. The maintainer uses a solar cell consisting of several cells in series. The solar cell has dimensions of 35.0 cm x 12.0 cm. It produces 1.00×10^2 mA of current at 14.5 V under full-sun intensity.

12. The number of electrons that pass one of the terminals during 1.00 s at 14.5 V under full-sun intensity is
- A. 1.60×10^{-20}
 - B. 1.60×10^{-17}
 - C. 6.25×10^{17}
 - D. 6.25×10^{20}
13. Increasing the area of the solar cell to 630 cm² would
- A. have no significant effect
 - B. decrease the current
 - C. increase the current
 - D. decrease the potential difference
14. To recharge a battery, electrons must be replaced. A typical automotive headlight operates with 1.0 A of current at 12 V. If the headlight is left burning for 1.0 h, what is the time required for the battery maintainer to replace the same number of electrons?
- A. 8.3×10^{-1} h
 - B. 1.0×10^1 h
 - C. 1.0×10^2 h
 - D. 1.0×10^3 h

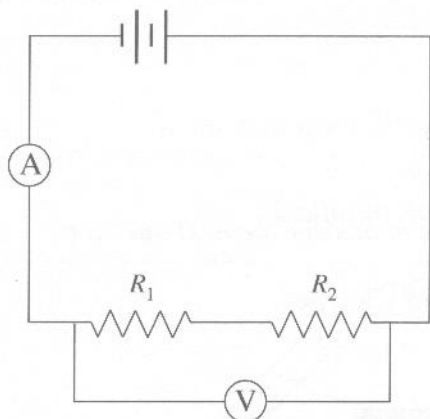
Numerical Response

5. The average amount of energy being given to each electron by the solar cell, expressed in scientific notation, is $b \times 10^{-w}$ J. The value of b is _____.

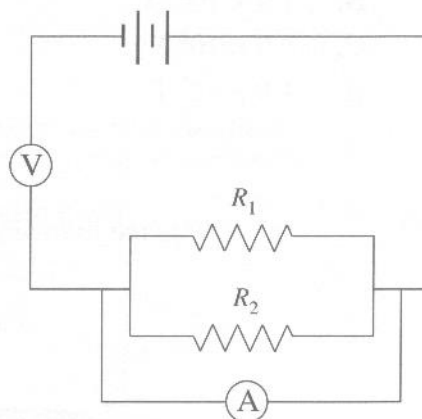
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

15. A student wishes to verify that $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ for resistors in parallel. He has two known resistors, R_1 and R_2 , a power source, an ammeter, and a voltmeter. Which circuit should he set up?

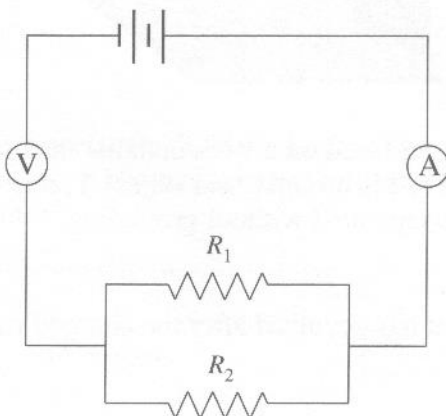
A.



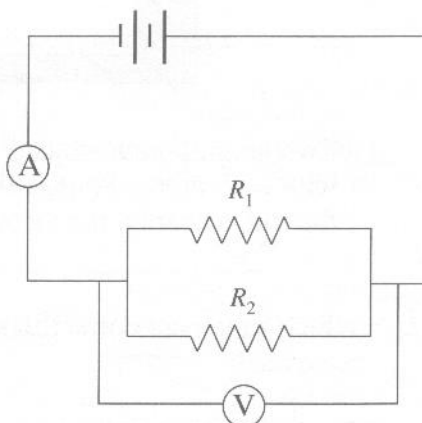
B.



C.

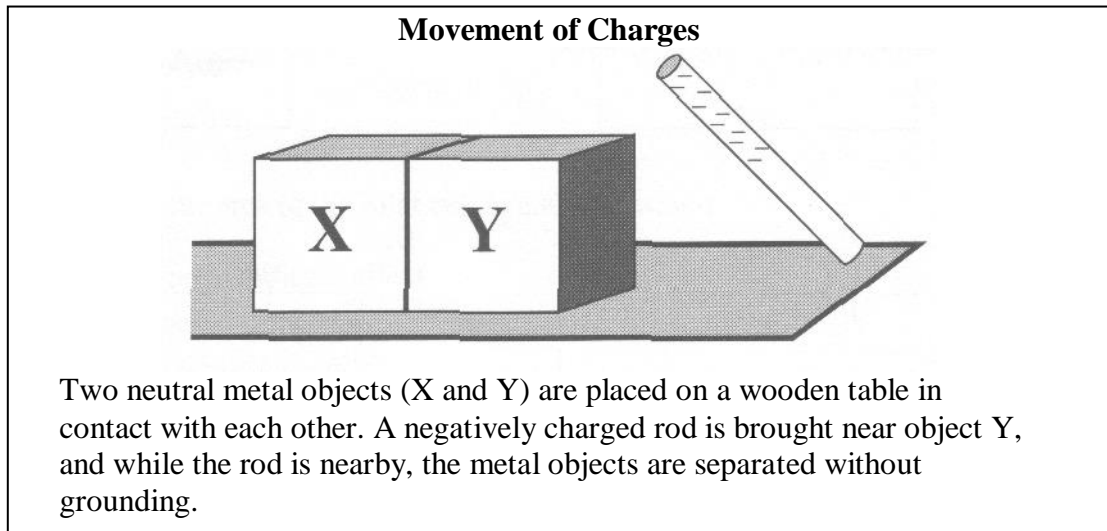


D.



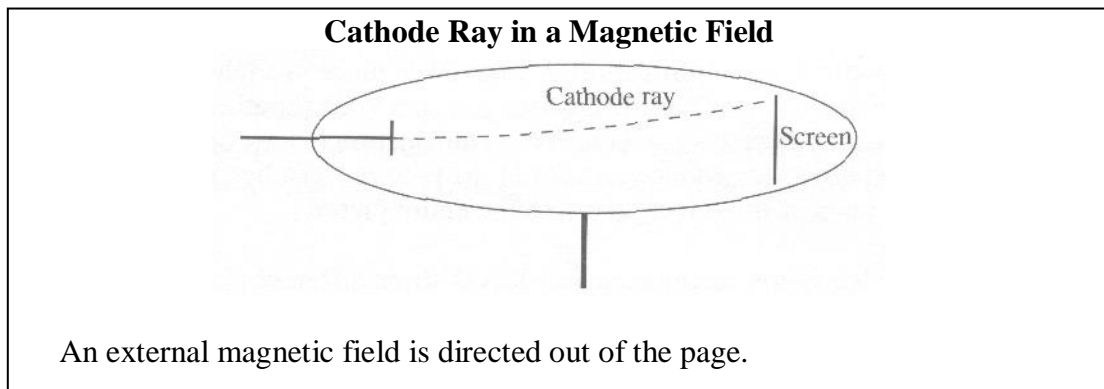
16. Lightning maintains the potential difference between the surface of Earth and the ionosphere. In a typical lightning strike, 20 C of charge is transferred from the surface of Earth to a cloud through a potential difference of 3.0×10^7 V in 3.10×10^{-3} s. The electrical energy released in the lightning discharge is
- A. 6.1×10^{13} J
 - B. 1.9×10^{11} J
 - C. 6.0×10^8 J
 - D. 1.9×10^6 J

Use the following information to answer the next question.

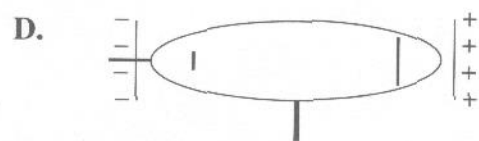
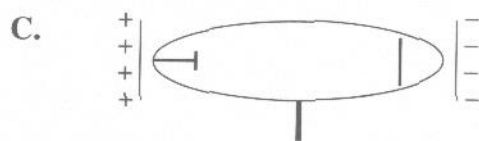
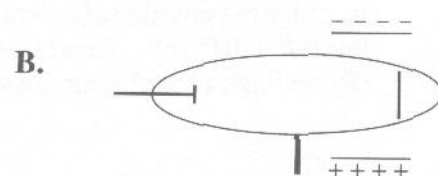
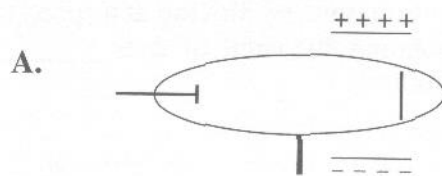


17. Which statement correctly describes what has occurred after the charged rod was removed?
- A. Object X received a negative charge by conduction, and object Y received a positive charge by conduction
 - B. Object X received a negative charge by induction, and object Y received a positive charge by induction
 - C. Objects X and Y both received a negative charge by induction
 - D. Objects X and Y both received a negative charge by conduction
18. Which of the following quantities must be represented as scalar?
- A. Velocity
 - B. Magnetic force
 - C. Acceleration
 - D. Electric potential

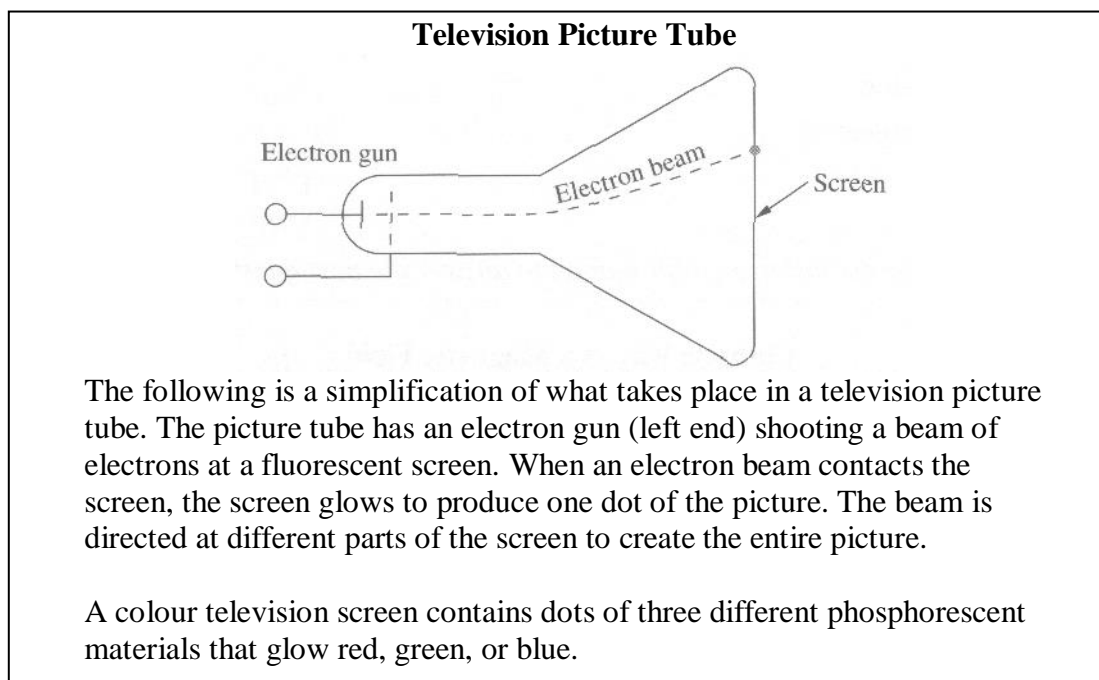
Use the following information to answer the next question.



19. A magnetic field directed out of the page caused the cathode rays to move up the screen. What arrangement of electric plates would cause them to return to the centre?



Use the following information to answer the next three questions.



Numerical Response

6. An electron from the beam hits an atom of the phosphor, causing it to make a transition to a higher energy level. A short time later, the atom makes a transition to the original state, releasing a photon of red light with wavelength $7.02 \times 10^{-7} \text{ m}$. In order to provide sufficient energy, the electron must be moving at a speed of at least $b \times 10^w \text{ m/s}$. Expressed in scientific notation, the value of b is _____.

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

Use your recorded answer from **Numerical Response 6** to answer **Numerical Response 7**.

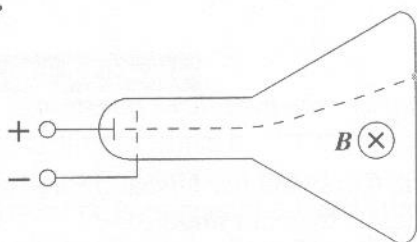
Numerical Response

7. The voltage that would be required to accelerate the electron to the speed recorded in Numerical Response 6, expressed in scientific notation, is $b \times 10^w$ V. The value of b is

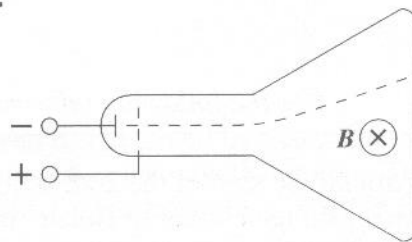
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

20. Assume that \square represents B out of the page and \otimes represents B into the page. The electrical polarity of the electron gun and magnetic field orientation that will cause the electron beam to pass through the tube and deflect upward is shown in

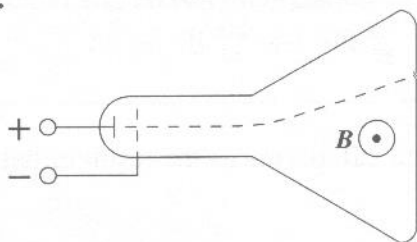
A.



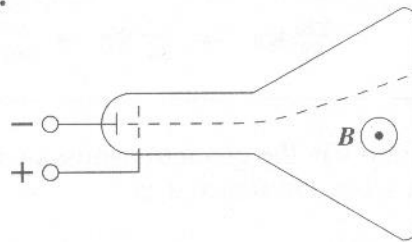
B.



C.



D.



21. Three common types of radiation occur during natural decay: alpha, beta, and gamma. Descriptions of alpha, beta, and gamma radiation, respectively, are

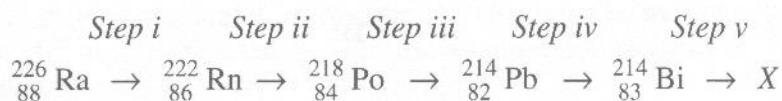
- A. electromagnetic radiation, He^{2+} , electrons
- B. electrons, electromagnetic radiation, He^{2+}
- C. He^{2+} , electrons, electromagnetic radiation
- D. He^{2+} , electromagnetic radiation, electrons

22. Some forms of radiation beams can be bent by passing them through an electric or magnetic field. This could be a useful process for focusing radioactive emissions. This method could be applied to
- A. alpha and beta radiation
 - B. alpha and gamma radiation
 - C. beta and gamma radiation
 - D. alpha, beta, and gamma radiation

Use the following information to answer the next three questions.

Around the start of the 20th century, Marie Curie and her husband Pierre used chemical techniques to isolate the radioactive element radium.

Steps in the decay sequence of Radium 226 were later established to be



23. If *Step v* in the given transmission of Radium 226 occurs as the result of beta emission, substance **X** is
- A. $^{213}_{82}\text{Pb}$
 - B. $^{214}_{84}\text{Po}$
 - C. $^{210}_{81}\text{Ti}$
 - D. $^{214}_{82}\text{Pb}$
24. The half-life of Radon 222 is 3.82 days. Given a 35.0 g sample, how many days will it take for the mass of the radon to be reduced to 2.19 g?
- A. 0.417 days
 - B. 8.37 days
 - C. 15.3 days
 - D. 16.0 days

25. Which other step is accomplished by beta emission?
- A. *Step i*
 - B. *Step ii*
 - C. *Step iii*
 - D. *Step iv*

Numerical Response

8. According to Einstein (1905), mass defect can be explained by assuming that an equivalent amount of energy is carried away by an energetic photon. The amount of energy equivalent to the mass defect could be predicted by the famous equation $E = mc^2$. Assuming that the mass defect is 9.00×10^{-30} kg, the frequency of the photon that corresponds to that energy, expressed in scientific notation, is $b \times 10^w$ Hz. The value of b is _____.

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

Use the following information to answer the next two questions.

Food preservation is an ongoing human concern. A new technology, food irradiation, preserves food by destroying parasites and micro-organisms, and inhibiting sprouting. This is accomplished by passing the food through a thick-walled chamber containing a source of radiation such as Cobalt-60 that produces gamma rays. The half-life of Cobalt-60 is 5.3 years.

26. In 1994, a new Cobalt-60 unit could irradiate 10 000 kg of potatoes per day. By the year 2010, the rate of flow of potatoes through this unit should be reduced to about
- A. 5000 kg per day
 - B. 2500 kg per day
 - C. 1200 kg per day
 - D. 600 kg per day

Use the following additional information to answer the next question.

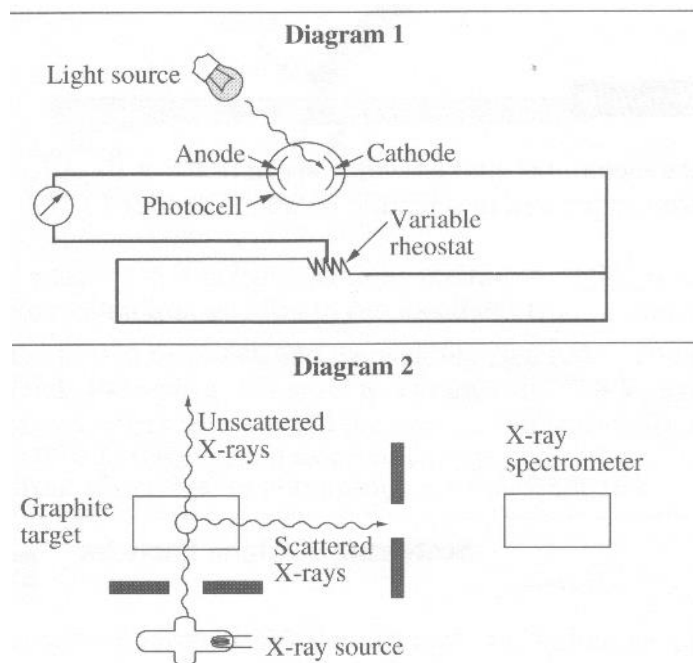
Excerpt from the Periodic Table

5	B	6	C	7	N	8	O	9	F	10	Ne
	2.0		2.5		3.0		3.5		4.0		—
Boron		Carbon		Nitrogen		Oxygen		Fluorine		Neon	
10.81		12.01		14.01		16.00		19.00		20.17	

27. If alpha radiation were used instead of gamma radiation, there might be a problem with transmutation of elements in the food. Which of the following transmutations produces alpha radiation?
- A. Oxygen to fluorine
 - B. Oxygen to neon
 - C. Carbon-12 to radioactive Carbon-14
 - D. Carbon to nitrogen
28. A fluorescent light tube contains a gas mixture at low pressure. When a current is passed through the tube, it gives off light energy because the
- A. electron orbitals of the gas atoms decay according to Maxwell's Laws
 - B. electrons of the gas atoms are initially excited to higher energy levels
 - C. electrical energy transforms to vibrational energy in the atomic band
 - D. electrical current is scattered by the nuclei of the gas atoms

Use the following information to answer the next four questions.

Following the introduction of quantum theory in the early 1900s, the centuries-old arguments concerning the wave or particle nature of light and other electromagnetic radiation were reinvestigated. The diagrams below depict experiments performed to demonstrate the particle properties of electromagnetic waves.



29. The two experiments depicted successfully proved that EM wave photons are similar to particles in that they both have
- A. wavelength and momentum
 - B. energy and momentum
 - C. energy and wavelength
 - D. energy and frequency
30. The experiments depicted in the diagrams were used to prove theories concerning particle properties of EM waves described by
- A. Einstein and Compton
 - B. Einstein and de Broglie
 - C. Einstein and Rutherford
 - D. Compton and de Broglie

31. Louis de Broglie proposed a hypothesis that was related to which of the following statements?
- A. The energy absorbed by an atom is the same as the energy released by the atom.
 - B. If light has particle properties, then particles may have wave properties.
 - C. The intensity of light controls the current in the photoelectric effect.
 - D. Energy and mass are related.

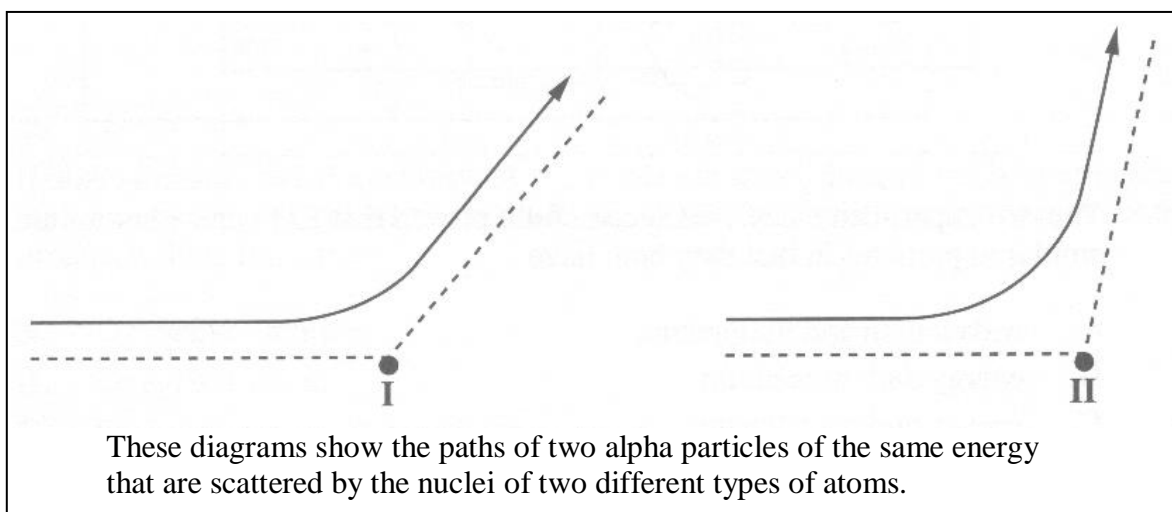
Numerical Response

9. If the photoelectron is emitted with a speed of 6.8×10^5 m/s, the kinetic energy of the electron, expressed in scientific notation, is **a.b** $\times 10^{-cd}$ J.
The values of **a**, **b**, **c**, and **d** are _____, _____, _____, and _____.

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

Use the following information to answer the next question.

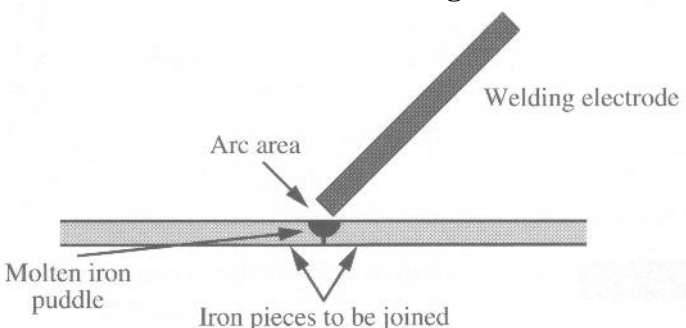
Scattering of Alpha Particles



32. Which statement correctly explains the difference in the deflection of the alpha particle?
- A. The size of nucleus II is greater than the size of nucleus I.
 - B. The mass of nucleus II is greater than the mass of nucleus I.
 - C. The charge on nucleus II is greater than the charge on nucleus I.
 - D. The charge on the particle scattered by nucleus II is greater than the charge on the particle scattered by nucleus I.

Use the following information to answer the next two questions.

Electrical Welding



The diagram illustrates the electrical welding process. A horizontal bar represents the 'Iron pieces to be joined'. A diagonal line represents the 'Welding electrode'. An 'Arc area' is shown between the electrode and the iron. A 'Molten iron puddle' is formed at the point of contact. Arrows point from the labels to their respective parts in the diagram.

An electric-arc welder can join iron pieces by melting a section of each piece and allowing the molten iron puddles to run together. Upon cooling, one piece is formed. The heat required is produced by an electrical discharge (the arc) between the iron to be joined and the welding electrode. To join pieces of iron 0.30 cm thick, the welder, when set to an output of 32.0 V, will send 100 A of current between the electrode and the iron. A transformer is used to convert from 220 V to the required welding voltage.

Numerical Response

10. The arc welder is operated from a 220 V outlet and used to join the pieces of iron. The amount of current that flows through the outlet is _____ A.

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

33. If the energy supplied to the arc welder is supplied from a wall outlet at home, the welder requires a second transformer to convert from 110 V to an operating voltage of 220 V. Several procedures are described below.
- I. Double the number of turns on the primary coil of the second transformer
 - II. Half the number of turns on the primary coil of the second transformer
 - III. Double the number of turns on the secondary coil of the second transformer
 - IV. Half the number of turns on the secondary coil of the second transformer

Which of these procedures would produce the desired result?

- A. I or III
- B. I or IV
- C. II or III
- D. II or IV

34. A group of hydrogen atoms are in the excited $n = 4$ state. As they drop to the ground state, the maximum number of **different** wavelengths of photons that could be emitted is
- A. 1
 - B. 2
 - C. 4
 - D. 6

Numerical Response

11. The energy of an electron in the third energy level of hydrogen is – _____ eV.

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

Use the following information to answer the next two questions.

An electron drops from the third energy level to the second energy level of an excited hydrogen atom.

35. The wavelength of the photon emitted is
- A. $5.45 \times 10^{-7} \text{ m}$
 - B. $6.55 \times 10^{-7} \text{ m}$
 - C. $1.53 \times 10^6 \text{ m}$
 - D. $1.83 \times 10^6 \text{ m}$

Numerical Response

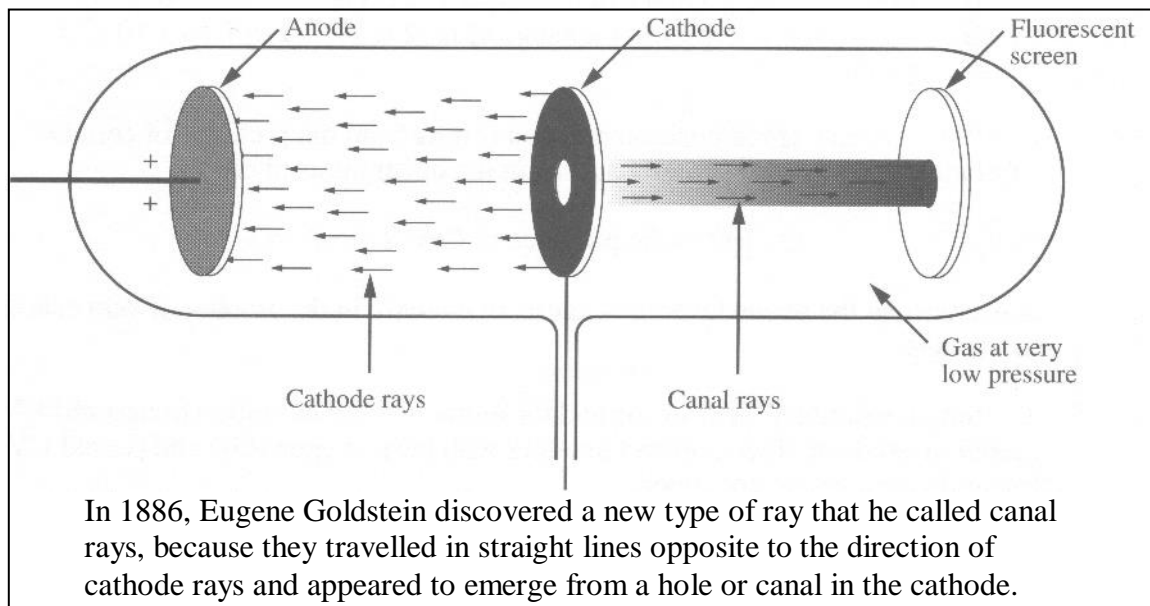
12. The energy of the emitted photon, expressed in scientific notation, is $b \times 10^{-w} \text{ J}$. The value of b is _____.

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

36. When a certain material is irradiated with ultraviolet light of wavelength $4.0 \times 10^{-8} \text{ m}$, it releases photoelectrons having a maximum kinetic energy of 30.0 eV. The work function of the material is
- A. $1.7 \times 10^{-19} \text{ J}$
 - B. $4.8 \times 10^{-18} \text{ J}$
 - C. $5.0 \times 10^{-18} \text{ J}$

D. $4.0 \times 10^{-9} \text{ J}$

Use the following information to answer the next question.



37. By placing either a magnetic or electric field between the cathode and the screen, the canal rays can be bent. This would indicate they are
- A. charged particles
 - B. mechanical waves
 - C. uncharged particles
 - D. electromagnetic waves