Sample Questions for the AP Physics 2 Exam

Multiple-Choice Questions

NOTE: *To simplify calculations, you may use g = 10 m/s² in all problems.*

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

Questions 1–3 refer to the following material.

An isolated, neutral lambda particle (Λ^0) is moving to the right with speed v. It then decays into a proton and a pion $(\Lambda^0 \rightarrow p^+ + \pi^-)$. The following are the masses of the three particles:

Lambda: $1115.7\, MeV/c^2$

Proton: $938.3\, MeV/c^2$

Pion: $139.6\, MeV/c^2$

1. How much energy is released when the Λ^0 decays?

   (A) 2193.6 MeV

   (B) 1914.4 MeV

   (C) 317.0 MeV

   (D) 37.8 MeV

Enduring Understanding	Learning Objective	Science Practice
4.C: Interactions with other objects or systems can change the total energy of a system.	**4.C.4.1:** The student is able to apply mathematical routines to describe the relationship between mass and energy and apply this concept across domains of scale.	**2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena.

2. Which of the following indicates how the total linear momentum of the Λ^0 particles after the decay compares to the linear momentum of the before the decay and explains why?

(A) The momentum is in the same direction but has a smaller magnitude because the proton and pion have opposite charges and attract each other.

(B) The momentum is in the same direction but has a smaller magnitude because the proton and pion are emitted in opposite directions.

(C) The momentum is in the same direction and has the same magnitude because no external force acts on the system of particles.

(D) The momentum is in the same direction and has the same magnitude because the work done by the strong force is greater than the energy emitted during the decay.

Enduring Understanding	Learning Objective	Science Practice
5.D: The linear momentum of a system is conserved.	**5.D.3.3:** The student is able to make predictions about the velocity of the center of mass for interactions within a defined two-dimensional system.	**6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models.

3. At some later time, the proton and pion are both moving to the right in the plane of the page when they enter a magnetic field directed out of the page. Which of the following describes the directions of the magnetic forces on the proton and pion at the instant they enter the field?

(A) Proton: toward the top of the page Pion: toward the top of the page

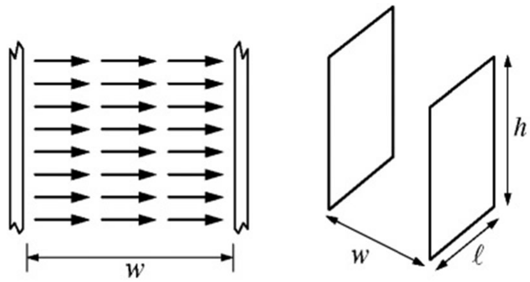
(B) Proton: toward the top of the page Pion: toward the bottom of the page

(C) Proton: toward the bottom of the page Pion: toward the bottom of the page

(D) Proton: toward the bottom of the page Pion: toward the top of the page

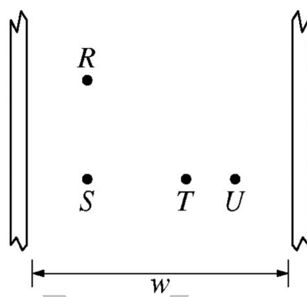
Enduring Understanding	Learning Objective	Science Practice
3.C: At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.	**3.C.3.1:** The student is able to use right-hand rules to analyze a situation involving a current-carrying conductor and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the magnetic field created by the current-carrying conductor.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.

Questions 4–7 refer to the following material.



Note: Figure not drawn to scale.

The figure above on the left represents the horizontal electric field near the center of two large, vertical parallel plates near Earth's surface. The plates have height h and length ℓ, and they are separated by a distance w, as shown on the right. The field has magnitude E. A small object with mass m = and charge $+q$, where $m = qE/g$, is released from rest at a point midway between the plates.



4. Points R, S, T, and U are located between the plates as shown in the figure above, with points R and T equidistant from point S. Let V_{RS} , V_{ST} , V_{TU} , and V_{RU} be the magnitudes of the electric potential differences between the pairs of points. How do the magnitudes of these potential differences compare?

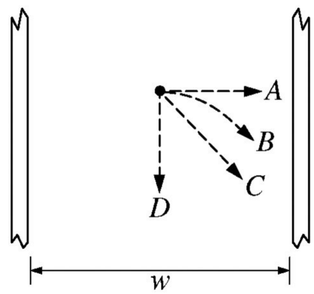
   (A) $V_{RU} > V_{ST} > V_{TU} > V_{RS}$

   (B) $V_{RU} > (V_{RS} = V_{ST} > V_{TU}$

   (C) $V_{Rs} > V_{TU} > V_{ST} > V_{RU}$

   (D) $V_{TU} > (V_{RS} = V_{ST}) > V_{RU}$

Enduring Understanding	Learning Objective	Science Practice
2.C: An electric field is caused by an object with electric charge.	**2.C.5.2:** The student is able to calculate the magnitude and determine the direction of the electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation.	**2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena.



5. After the object is released from rest, which of the paths shown in the figure above is a possible trajectory for the object?

(A) *A*

(B) *B*

(C) *C*

(D) *D*

Enduring Understandings	Learning Objectives	Science Practices
2.C: An electric field is caused by an object with electric charge. **3.B:** Classically, the acceleration of an object interacting with other objects can be predicted by using $\vec{a} = \frac{\sum \vec{F}}{m}$.	**2.C.1.1:** The student is able to predict the direction and the magnitude of the force exerted on an object with an electric charge q placed in an electric field E using the mathematical model of the relation between an electric force and an electric field: $\vec{F} = q\vec{E}$; a vector relation. **3.B.1.4:** The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations.	**6.4:** The student *can make claims and predictions about natural phenomena* based on scientific theories and models. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

6. Under which of the following new conditions could the gravitational force on the object be neglected?

(A) $h >> w$

(B) $q >> m$

(C) $qE >> mg$

(D) $Eh >> Ew$

Enduring Understandings	Learning Objectives	Science Practices
3.B: Classically, the acceleration of an object interacting with other objects can be predicted by using $\vec{a} = \frac{\sum \vec{F}}{m}$. **3.C:** At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.	**3.B.1.4:** The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations. **3.C.2.2:** The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.	**6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

7. The speed of a proton moving in an electric field changes from v_i to v_f over a certain time interval. Let the mass and charge of the proton be denoted as m_p and e. Through what potential difference did the proton move during the interval?

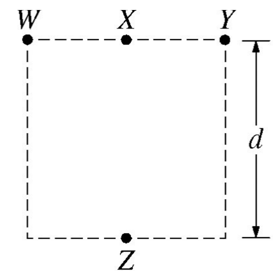
(A) $\frac{m_p}{2}\left(v_f^2 - 2v_i^2\right)$

(B) $\frac{m_p}{2e}\left(v_f^2 - v_i^2\right)$

(C) $\frac{m_p}{2}\left(v_f - v_i\right)$

(D) $\frac{m_p}{2e}\left(v_f - v_i\right)$

Enduring Understandings	Learning Objectives	Science Practices
2.C: An electric field is caused by an object with electric charge. **5.B:** The energy of a system is conserved.	**2.C.1.1:** The student is able to predict the direction and the magnitude of the force exerted on an object with an electric charge q placed in an electric field E using the mathematical model of the relation between an electric force and an electric field: $\vec{F} = q\vec{E}$; a vector relation. **2.C.1.2:** The student is able to calculate any one of the variables — electric force, electric charge, and electric field — at a point given the values and sign or direction of the other two quantities. **5.B.4.2:** The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively. **2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.



8. Four objects, each with charge +q, are held fixed on a square with sides of length d, as shown in the figure above. Objects X and Z are at the midpoints of the sides of the square. The electrostatic force exerted by object W on object X is F. What is the magnitude of the net force exerted on object X by objects W, Y, and Z ?

(A) $\frac{F}{4}$

(B) $\frac{F}{2}$

(C) $\frac{9F}{4}$

(D) $3F$

Enduring Understandings	Learning Objectives	Science Practices
3.B: Classically, the acceleration of an object interacting with other objects can be predicted by using $\vec{a} = \frac{\sum \vec{F}}{m}$. **3.C:** At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.	**3.B.2.1:** The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. **3.C.2.3:** The student is able to use mathematics to describe the electric force that results from the interaction of several separated point charges (generally 2 to 4 point charges, though more are permitted in situations of high symmetry).	**1.1:** The student can *create representations and models* of natural or man-made phenomena and systems in the domain. **1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively. **2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena.

9. Isolines of potential are drawn for the gravitational field of the Sun-Mercury system. The pattern of the isolines is identical to the pattern of equipotential lines for a system of two electrically charged objects with which of the following properties?

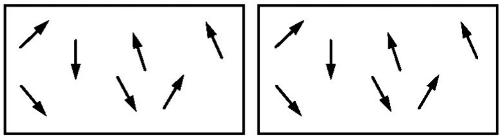
(A) The charges have the same sign and the same magnitude.

(B) The charges have the same sign and different magnitudes.

(C) The charges have opposite signs and the same magnitude.

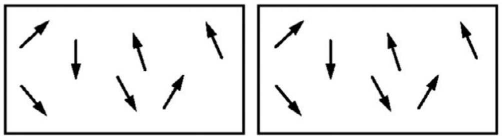
(D) The charges have opposite signs and different magnitudes.

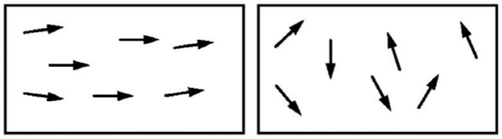
Enduring Understanding	Learning Objectives	Science Practices
2.E: Physicists often construct a map of isolines connecting points of equal value for some quantity related to a field and use these maps to help visualize the field.	**2.E.1.1:** The student is able to construct or interpret visual representations of the isolines of equal gravitational potential energy per unit mass and refer to each line as a gravitational equipotential. **2.E.2.2:** The student is able to predict the structure of isolines of electric potential by constructing them in a given electric field and make connections between these isolines and those found in a gravitational field.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively. **6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

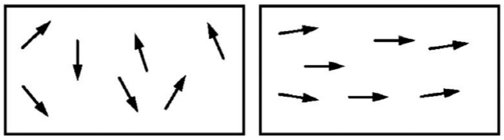


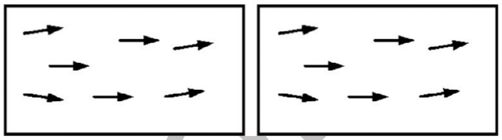
10. The figure above represents the random orientations of the magnetic dipoles in a block of iron and a block of lead. Iron is ferromagnetic and lead is diamagnetic. The two blocks are placed in a magnetic field that points to the right. Which of the following best represents the orientations of the dipoles when the field is present?

Iron Lead

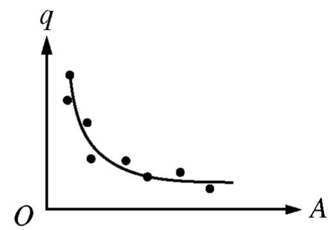
(A) 

(B) 

(C) 

(D) 

Enduring Understandings	Learning Objectives	Science Practices
2.D: A magnetic field is caused by a magnet or a moving electrically charged object. Magnetic fields observed in nature always seem to be produced either by moving charged objects or by magnetic dipoles or combinations of dipoles and never by single poles.	**2.D.3.1:** The student is able to describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet.	**1.2:** The student can *describe representations and models* of natural or man-made phenomena and systems in the domain.
4.E: The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.	**4.E.1.1:** The student is able to use representations and models to qualitatively describe the magnetic properties of some materials that can be affected by magnetic properties of other objects in the system.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.



11. Students are performing an experiment to determine how changing the area of the plates of a parallel-plate capacitor affects its behavior in a circuit. They connect a capacitor with plate area A to a battery and allow it to become fully charged. They take measurements that they believe will allow them to calculate the charge q on one plate of the capacitor. The students then repeat the procedure with other capacitors. The capacitors each have a different plate area but are otherwise identical. The students plot the calculated charge q as a function of plate area A. Their results, including a best fit to the data, are represented above. Is this graph a reasonably accurate representation of the relationship between q and A?

(A) Yes, because the relationship should result in a graph that is curved and decreasing.

(B) No, because the relationship should result in a graph that is linear and decreasing.

(C) No, because the relationship should result in a graph that is linear and increasing.

(D) No, because the relationship should result in a graph that is curved and increasing.

Enduring Understanding	Learning Objectives	Science Practice
4.E: The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.	**4.E.4.3:** The student is able to analyze data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors. **4.E.5.3:** The student is able to plan data collection strategies and perform data analysis to examine the values of currents and potential differences in an electric circuit that is modified by changing or rearranging circuit elements, including sources of emf, resistors, and capacitors.	**5.1:** The student can *analyze data* to identify patterns or relationships.

12. Some students experimenting with an uncharged metal sphere want to give the sphere a net charge using a charged aluminum pie plate. Which of the following steps would give the sphere a net charge of the same sign as the pie plate?

    (A) Bringing the pie plate close to, but not touching the metal sphere, then moving the pie plate away

    (B) Bringing the pie plate close to, but not touching, the metal sphere, then momentarily touching a grounding wire to the metal sphere

    (C) Bringing the pie plate close to, but not touching, the metal sphere, then momentarily touching a grounding wire to the pie plate

    (D) Touching the pie plate to the metal sphere

Enduring Understandings	Learning Objectives	Science Practice
4.E: The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems. **5.C:** The electric charge of a system is conserved.	**4.E.3.5:** The student is able to explain and/or analyze the results of experiments in which electric charge rearrangement occurs by electrostatic induction, or is able to refine a scientific question relating to such an experiment by identifying anomalies in a data set or procedure. **5.C.2.2:** The student is able to design a plan to collect data on the electrical charging of objects and electric charge induction on neutral objects and qualitatively analyze that data.	**4.2:** The student can *design a plan* for collecting data to answer a particular scientific question.

13. An ideal fluid is flowing with a speed of $12\text{cm}/\text{s}$ through a pipe of diameter 5 cm. The pipe splits into three smaller pipes, each with a diameter of 2 cm. What is the speed of the fluid in the smaller pipes?

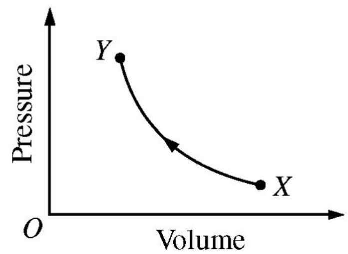
(A) $4\text{cm}/\text{s}$

(B) $12\text{cm}/\text{s}$

(C) $25\text{cm}/\text{s}$

(D) $75\text{cm}/\text{s}$

Enduring Understanding	Learning Objective	Science Practice
5.F: Classically, the mass of a system is conserved.	**5.F.1.1:** The student is able to make calculations of quantities related to flow of a fluid using mass conservation principles (the continuity equation).	**2.2:** The student can *apply mathematical routines* to quantities that describe natural phenomena.



14. The graph above shows the pressure as a function of volume for a sample of gas that is taken from state X to state Y at constant temperature. Which of the following indicates the sign of the work done on the gas, and whether thermal energy is absorbed or released by the gas during this process?

	Work done	Thermal energy
(A)	Positive	Absorbed
(B)	Positive	Released
(C)	Negative	Absorbed
(D)	Negative	Released

Enduring Understanding	Learning Objective	Science Practice
5.B: The energy of a system is conserved.	**5.B.7.1:** The student is able to predict qualitative changes in the internal energy of a thermodynamic system involving transfer of energy due to heat or work done and justify those predictions in terms of conservation of energy principles.	**6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models.

15. Two samples of ideal gas in separate containers have the same number of molecules and the same temperature, but the molecular mass of gas X is greater than that of gas Y. Which of the following correctly compares the average speed of the molecules of the gases and the average force the gases exert on their respective containers?

	Average speed of Molecules	Average Force on container
(A)	Greater for gas X	Greater for gas X
(B)	Greater for gas X	The forces cannot be compared without knowing the volumes of the gases.
(C)	Greater for gas Y	Greater for gas Y
(D)	Greater for gas Y	The forces cannot be compared without knowing the volumes of the gases.

Enduring Understanding	Learning Objectives	Science Practices
7.A: The properties of an ideal gas can be explained in terms of a small number of macroscopic variables including temperature and pressure.	**7.A.1.1:** The student is able to make claims about how the pressure of an ideal gas is connected to the force exerted by molecules on the walls of the container, and how changes in pressure affect the thermal equilibrium of the system. **7.A.2.2:** The student is able to connect the statistical distribution of microscopic kinetic energies of molecules to the macroscopic temperature of the system and to relate this to thermodynamic processes.	**6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models. **7.1:** The student can *connect phenomena and models* across spatial and temporal scales. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

16. Three different gas samples that have the same number of molecules and are at room temperature are kept at different pressures. A lab technician has determined the molecular mass of each gas and recorded the pressure and molecular mass of each sample in the table below.

Gas	Molecular Mass (u)	Pressure (¥100kPa)
X	2.0	6.0
Y	4.0	12
Z	40	1.0

Which of the following ranks the density ρ of the gas samples?

(A) $\rho_x = \rho_y > \rho_Z$

(B) $\rho_y > \rho_Z > \rho_X$

(C) $\rho_Z > \rho_X = \rho_Y$

(D) $\rho_Z > \rho_Y > \rho_X$

Enduring Understandings	Learning Objectives	Science Practices
1.A: The internal structure of a system determines many properties of the system.	**1.A.5.2:** The student is able to construct representations of how the properties of a system are determined by the interactions of its constituent substructures.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.
1.E: Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.	**1.E.1.2:** The student is able to select from experimental data the information necessary to determine the density of an object and/ or compare densities of several objects.	**6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models.
		7.1: The student can *connect phenomena and models* across spatial and temporal scales.

17. Light from a source that produces a single frequency passes through a single slit A. The diffraction pattern on a screen is observed. Slit A is then replaced by slit B, and the new pattern is observed to have fringes that are more closely spaced than those in the first pattern. Which of the following is a possible explanation for why the spacings are different?

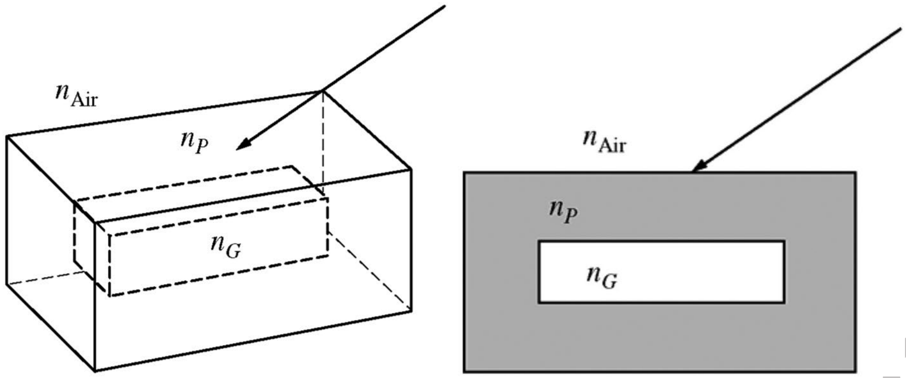
    (A) Slit A is wider than slit B.

    (B) Slit B is wider than slit A.

    (C) The distance between the light source and the slit is greater for slit A than for slit B.

    (D) The distance between the light source and the slit is greater for slit B than for slit A.

Enduring Understanding	Learning Objective	Science Practices
6.C: Only waves exhibit interference and diffraction.	**6.C.2.1:** The student is able to make claims about the diffraction pattern produced when a wave passes through a small opening and to qualitatively apply the wave model to quantities that describe the generation of a diffraction pattern when a wave passes through an opening whose dimensions are comparable to the wavelength of the wave.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively. **6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.



18. Students in a lab group are given a plastic block with a hollow space in the middle, as shown in the figures above. The index of refraction n_P of the plastic is known. The hollow space is filled with a gas, and the students are asked to collect the data needed to find the index of refraction n_G of the gas. The arrow represents a light beam that they shine into the plastic. They take the following set of measurements:

Angle of incidence of the light in the air above the plastic block	30°
Angle of refraction of the beam as it enters the plastic from the air	45°
Angle of refraction of the beam as it enters the plastic from the gas	45°

The three measurements are shared with a second lab group. Can the second group determine a value of n_G from only this data?

(A) Yes, because they have information about the beam in air and in the plastic above the gas.

(B) Yes, because they have information about the beam on both sides of the gas.

(C) No, because they need additional information to determine the angle of the beam in the gas.

(D) No, because they do not have multiple data points to analyze.

Enduring Understanding	Learning Objective	Science Practice
6.E: The direction of propagation of a wave such as light may be changed when the wave encounters an interface between two media.	**6.E.3.2:** The student is able to plan data collection strategies as well as perform data analysis and evaluation of the evidence for finding the relationship between the angle of incidence and the angle of refraction for light crossing boundaries from one transparent material to another (Snell's law).	**5.3:** The student can *evaluate the evidence provided by data sets* in relation to a particular scientific question.

19. The ground state of a certain type of atom has energy $-E_0$. What is the wavelength of a photon with enough energy to ionize an atom in the ground state and give the ejected electron a kinetic energy of $2E_0$?

(A) $\frac{hc}{3E_0}$

(B) $\frac{hc}{2E_0}$

(C) $\frac{hc}{E_0}$

(D) $\frac{2hc}{E_0}$

Enduring Understanding	Learning Objective	Science Practices
5.B: The energy of a system is conserved.	**5.B.8.1:** The student is able to describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed.	**1.2:** The student can *describe representations and models* of natural or man-made phenomena and systems in the domain. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

20. A hypothetical one-electron atom in its highest excited state can only emit photons of energy $2E$, $3E$, and $5E$. Which of the following is a possible energy-level diagram for the atom?

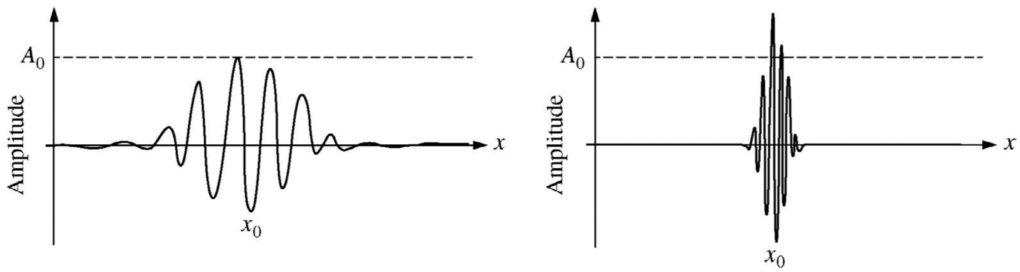
(A) ______ $5E$
______ $3E$
______ 0

(B) ______ $3E$
______ $2E$
______ 0

(C) ______ $5E$
______ $3E$
______ $2E$
______ 0

(D) ______ $10E$
______ $8E$
______ $5E$
______ 0

Enduring Understandings	Learning Objectives	Science Practices
1.A: The internal structure of a system determines many properties of the system. **5.B:** The energy of a system is conserved.	**1.A.4.1:** The student is able to construct representations of the energy level structure of an electron in an atom and to relate this to the properties and scales of the systems being investigated. **5.B.8.1:** The student is able to describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed.	**1.1:** The student can *create representations and models* of natural or man-made phenomena and systems in the domain. **1.2:** The student can *describe representations and models* of natural or man-made phenomena and systems in the domain.



21. The figure above shows graphical representations of the wave functions of two particles, X and Y, that are moving in the positive x-direction. The maximum amplitude of particle X's wave function is A_0 . Which particle has a greater probability of being located at position x_0 at this instant, and why?

    (A) Particle X, because the wave function of particle X spends more time passing through x_0 than the wave function of particle Y

    (B) Particle X, because the wave function of particle X has a longer wavelength than the wave function of particle Y

    (C) Particle Y, because the wave function of particle Y is narrower than the wave function of particle X

    (D) Particle Y, because the wave function of particle Y has a greater amplitude near x_0 than the wave function of particle X

Enduring Understanding	Learning Objective	Science Practice
7.C: At the quantum scale, matter is described by a wave function, which leads to a probabilistic description of the microscopic world.	**7.C.1.1:** The student is able to use a graphical wave function representation of a particle to predict qualitatively the probability of finding a particle in a specific spatial region.	**1.4:** The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.

Directions: For questions 22–25 below, two of the suggested answers will be correct. Select the two answers that are best in each case, and then fill in both of the corresponding circles on the answer sheet.

22. On a day that is warm and sunny, a car is parked in a location where there is no shade. The car's windows are closed. The air inside the car becomes noticeably warmer than the air outside. Which of the following factors contribute to the higher temperature? Select two answers.

    (A) Hotter air rises to the roof of the car and cooler air falls to the floor.

    (B) The body of the car insulates the air inside the car.

    (C) Electromagnetic radiation from the Sun enters the car and is absorbed by the materials inside.

    (D) The body of the car reflects electromagnetic radiation.

Enduring Understanding	Learning Objective	Science Practice
5.B: The energy of a system is conserved.	**5.B.6.1:** The student is able to describe the models that represent processes by which energy can be transferred between a system and its environment because of differences in temperature: conduction, convection, and radiation.	**1.2:** The student can *describe representations and models* of natural or man-made phenomena and systems in the domain.

23. A fixed amount of ideal gas is kept in a container of fixed volume. The absolute pressure P, in pascals, of the gas is plotted as a function of its temperature T, in degrees Celsius. Which of the following are properties of a best fit curve to the data? Select two answers.

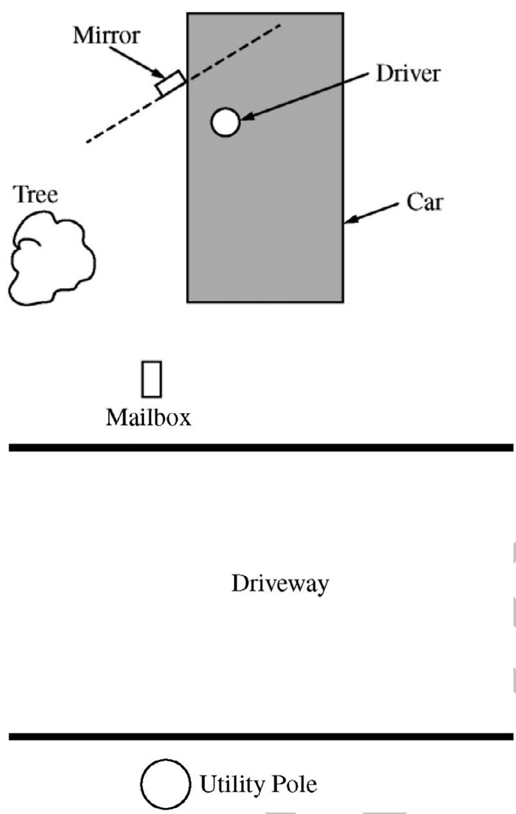
    (A) Having a positive slope

    (B) Passing through the origin

    (C) Having zero pressure at a certain negative temperature

    (D) Approaching zero pressure as temperature approaches infinity

Enduring Understanding	Learning Objectives	Science Practices
7.A: The properties of an ideal gas can be explained in terms of a small number of macroscopic variables including temperature and pressure.	**7.A.3.1:** The student is able to extrapolate from pressure and temperature or volume and temperature data to make the prediction that there is a temperature at which the pressure or volume extrapolates to zero. **7.A.3.3:** The student is able to analyze graphical representations of macroscopic variables for an ideal gas to determine the relationships between these variables and to ultimately determine the ideal gas law $PV = nRT$.	**5.1:** The student can *analyze data* to identify patterns or relationships. **6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models.



24. A driver is backing a car off a lawn into a driveway while using the side-view mirror to check for obstacles. The figure above shows a top view of the car and some objects near the car. The mirror is a plane mirror, and the dashed line shows the angle of its plane. Which of the following should the driver be able to see in the mirror by just turning her head without moving her head from the position shown? Select two answers.

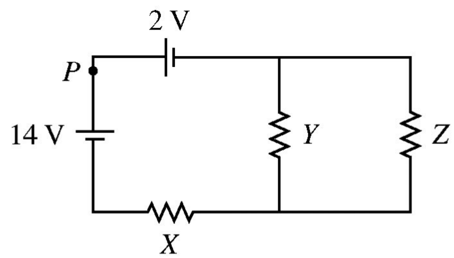
(A) Herself

(B) The tree

(C) The mailbox

(D) The utility pole

Enduring Understanding	Learning Objective	Science Practices
6.E: The direction of propagation of a wave such as light may be changed when the wave encounters an interface between two media.	**6.E.2.1:** The student is able to make predictions about the locations of object and image relative to the location of a reflecting surface. The prediction should be based on the model of specular reflection with all angles measured relative to the normal to the surface.	**6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models. **7.2:** The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.



25. The figure above shows a circuit containing two batteries and three identical resistors with resistance R. Which of the following changes to the circuit will result in an increase in the current at point P ? Select two answers.

(A) Reversing the connections to the 14 V battery

(B) Removing the 2 V battery and connecting the wires to close the left loop

(C) Rearranging the resistors so all three are in series

(D) Removing the branch containing resistor Z

Enduring Understandings	Learning Objectives	Science Practice
4.E: The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems. **5.B:** The energy of a system is conserved. **5.C:** The electric charge of a system is conserved.	**4.E.5.2:** The student is able to make and justify a qualitative prediction of the effect of a change in values or arrangements of one or two circuit elements on currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel. **5.B.9.5:** The student is able to use conservation of energy principles (Kirchhoff's loop rule) to describe and make predictions regarding electrical potential difference, charge, and current in steady-state circuits composed of various combinations of resistors and capacitors. **5.C.3.4:** The student is able to predict or explain current values in series and parallel arrangements of resistors and other branching circuits using Kirchhoff's junction rule and relate the rule to the law of charge conservation.	**6.4:** The student can *make claims and predictions about natural phenomena* based on scientific theories and models.