Name KEY

31 Questions

Select the one response that best answers each question.

1) A perfect Carnot engine operates between the temperatures of 300K and 700K, drawing 60 kJ of heat from the 700K reservoir in each cycle. How much heat is dumped into the 300K reservoir in each cycle?

A) 38 kJ B) 26 kJ See below C) 42 kJ D) 34 kJ E) 30 kJ

2) Materials in which the electrons are bound very loosely to the nuclei and can move about freely within the material are referred to as ____________________.

See notes

A) semiconductors B) insulators C) polar D) conductors

3) The electric field 2.8 cm from a small object points toward the object with a strength of 180,000 N/C. What is the object's charge? $E = kq/r^2$

q is negative

A) +16 nC $\therefore q = \frac{Er^2}{k}$ B) +17 nC C) −17 nC D) −16 nC

4) What is the coefficient of performance of a Carnot heat pump used to remove heat from ice at 0.0°C and add heat to a room at 20.0°C? HINT: The heat added to the room is the 'get'. See below

A) 293 B) 1.00 C) 14.7 D) 0.00 E) 20.0

5) A charge Q = 3 μC is located at the origin. The electric field created by this charge at a point of coordinates (x = 2 m, y = 0m) is equal to ________.

$E = \frac{kq}{r^2}$ radially away from +

A) 13.5×10^3 N/C $\hat{j}$ B) 0.75×10^3 N/C $\hat{i}$ C) 6.74×10^3 N/C $\hat{i}$ D) 13.5×10^9 N/C $\hat{i}$

6) A proton is placed in an electric field whose magnitude is 700 N/C. What is the magnitude and direction of the acceleration of this proton due to this field? The mass of a proton is 1.67×10^{-27} kg. The charge on a proton is +1.6×10^{-19} C.

$\vec{F} = q\vec{E} = m\vec{a}$

$\vec{a} = \frac{q\vec{E}}{m}$

A) 6.71×10^{10} m/ s^2 opposite to the direction of the electric field
B) it is impossible to say without knowing the sign of the electric field.
C) 6.71×10^9 m/ s^2 opposite to the direction of the electric field
D) 6.71×10^{10} m/ s^2 in the direction of the electric field

7) Is it possible to transfer heat from a hot reservoir to a cold reservoir?

A) Yes, but work will have to be done.
B) Yes; this will happen naturally.
C) No.
D) Theoretically yes, but it hasn't been accomplished yet.

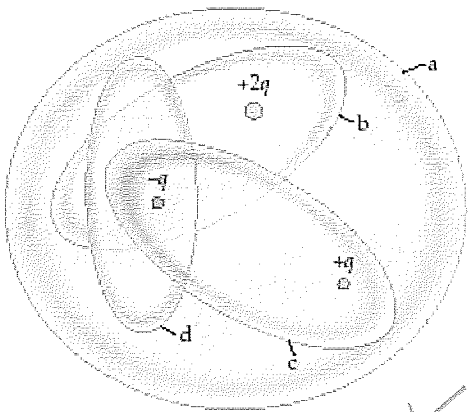
You can answer this by looking @ heat Engine diagrams on Formula sheet.

8) If the electric potential is given by $V = xy - 3z^{-2}$, then the electric field has a y-component of _______.

A) y B) −x. C) x D) $x + y - 6z^{-3}$

$E_y = -\frac{\partial V}{\partial y} = -(x)$

9) The figure shows four Gaussian surfaces surrounding a distribution of charges. Which Gaussian surfaces have an electric flux of $+q/\varepsilon_0$ through them?



$$\underbrace{\oint \vec{E}\cdot d\vec{A}}_{\Phi_E} = \frac{Q_{enclosed}}{\varepsilon_0}$$

$$\Phi_{E_a} = \frac{(+2q - q + q)}{\varepsilon_0} = 2q/\varepsilon_0$$
$$\Phi_{E_b} = q/\varepsilon_0$$
$$\Phi_{E_c} = 0$$
$$\Phi_{E_d} = -q/\varepsilon_0$$

A) a B) b C) b and d D) d

10) If two uncharged objects are rubbed together and one of them acquires a positive charge, then the other one ____________.

A) also acquires a positive charge
B) acquires a negative charge.
C) remains the same.
D) may or may not acquire a negative charge.

11) A negatively charged rod is brought near one end of an uncharged metal bar. The end of the metal bar farthest from the charged rod will be charged ____________. Class demo. || Likes repel.

A) neutral B) none of these C) negative D) positive

12) A refrigerator removes heat from the freezing compartment at the rate of 20 kJ and ejects 24 kJ into a room per cycle. How much work is required in each cycle? $Q_L + W = Q_H$

A) 44 kJ B) 22 kJ C) 20 kJ D) 4 kJ E) 24 kJ

$\therefore W = Q_H - Q_L = 24 - 20 = 4\,kJ$

13) A metal sphere of radius 2.0 cm carries a charge of 3.0 μC. What is the magnitude of the electric field 6.0 cm from the center of the sphere? Gauss OR symmetry ⇒ this looks like a point charge!

A) 7.5×10^6 N/C B) 9.3×10^6 N/C C) 5.7×10^6 N/C D) 3.4×10^6 N/C

$$E = \frac{kq}{r^2} = \frac{8.99\times10^9\,(3\times10^{-6})}{(0.06)^2}$$

14) Is it possible to transfer heat from a cold reservoir to a hot reservoir?

A) Yes; this will happen naturally.
B) No.
C) Theoretically yes, but it hasn't been accomplished yet.
D) Yes, but work will have to be done.

This is the opposite of question #17. Answer is on the formula sheet.

15) A charge Q is positioned at the center of a sphere of radius R. The electric flux through the sphere is equal to Φ. If the charge Q is now placed at the center of a cube, the electric flux through the surface of the cube is equal to ____________________.

$\underbrace{\oint \vec{E}\cdot d\vec{A}}_{\Phi_E} = \underbrace{Q_{enclosed}/\varepsilon_0}$ SAME for both Cases!

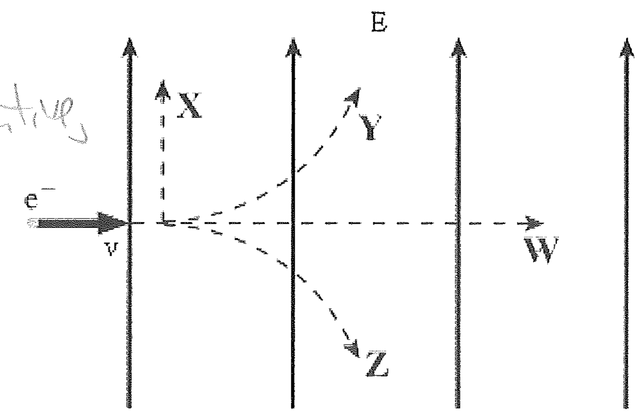
A) Φ.
B) 2Φ
C) Φ/2
D) The value of the flux depends on the dimensions of the cube

16) A 10 μC charge is placed at the origin and a 20 μC charge is placed on the x-axis at x = 40 cm. If an electron is placed on the y-axis at y = 30 cm, what is the magnitude of the force it will experience? The charge on an electron is -1.6×10^{-19} C. See below

A) 1.37×10^{-13} N
B) 1.23×10^{-13} N
C) 4.92×10^{-13} N
D) 2.46×10^{-13} N

17) An electron is initially moving to the right when it enters a uniform electric field directed upwards. Which trajectory shown below will the electron follow?

$\vec{F} = q\vec{E}$
Since q is negative, F in opposite direction of $\vec{E}$



A) Trajectory W
B) Trajectory X
C) Trajectory Y
D) Trajectory Z

18) A negative charge, if free, tries to move ____________________.

See NOTES

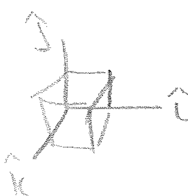
A) from high voltage to low voltage
B) from low voltage to high voltage
C) in the direction of the electric field
D) more information is needed

19) An advantage in evaluating surface integrals related to Gauss's law for symmetric charge distributions is ______.

This requires an understanding of how we use GAUSS

A) the flux is inward
B) the flux is outward
} depends on specifics of problem
C) the electric field is of constant magnitude on certain surfaces ⟵ Best Answer (See notes)
D) the electric field is a constant on any surface ⟶ depends on choice of surface

20) A region of space contains an electric field $E = 2x\,\hat{i} - 3y\,\hat{j} + 0\,\hat{k}$, in SI units. A cube with sides of length 2 meters has one corner on the origin and extends along the +x, +y, and +z axes. Find the magnitude of the flux through the top surface of the cube. To be clear, that surface is parallel to the x-z plane and contains the point (2,2,2).



A) 12 Nm^2/C
B) 24 Nm^2/C
C) 48 Nm^2/C
D) 0

$d\vec{A} = dx\,dz\,\hat{j}$

$\int_{TOP} \vec{E}\cdot d\vec{A} = \int_{Top}(-3\overset{2}{y}\,dx\,dz) = -6\underbrace{\int_{Top} dx\,dz}_{\text{Area }4} = -24\ \frac{Nm^2}{C}$

$\vec{F} = q\vec{E}$

21) When static equilibrium is established for a charged conductor, the electric field just $\boxed{\text{inside}}$ the surface of the conductor is ________________________.

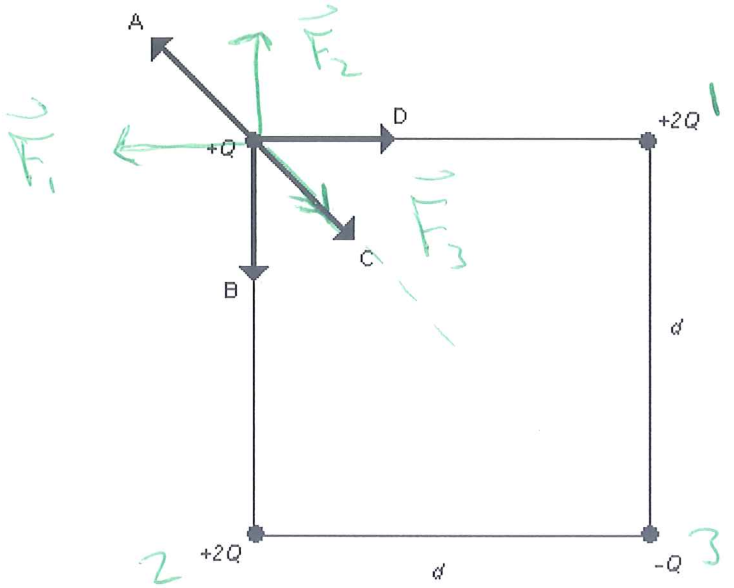
See notes

A) zero ✓ Must be the case if static
B) opposite to the field outside.
C) cannot be determined
D) equal to the field outside.

22) The temperature inside a Carnot refrigerator is 2.0°C. The temperature in the kitchen(where the refrigerator is located) is 22°C . The heat extracted from the refrigerator is 24.7 x 10^3 J/s. What power is needed to operate this refrigerator? HINT: The heat extracted from the refrigerator is the 'get'. See below

A) 1.6 kW
B) 1.9 kW
C) 1.7 kW
D) 1.5 kW
E) 1.8 kW ✓

23) Four point charges of varying magnitude and sign are arranged on the corners of the square of side d as shown in the figure. Which of the arrows shown represents the net force acting on the point charge with a charge $+Q$?



$|\vec{F}_1| = |\vec{F}_2|$

NOTE that these two forces have a symmetry so that resulting force is $\vec{A}$.

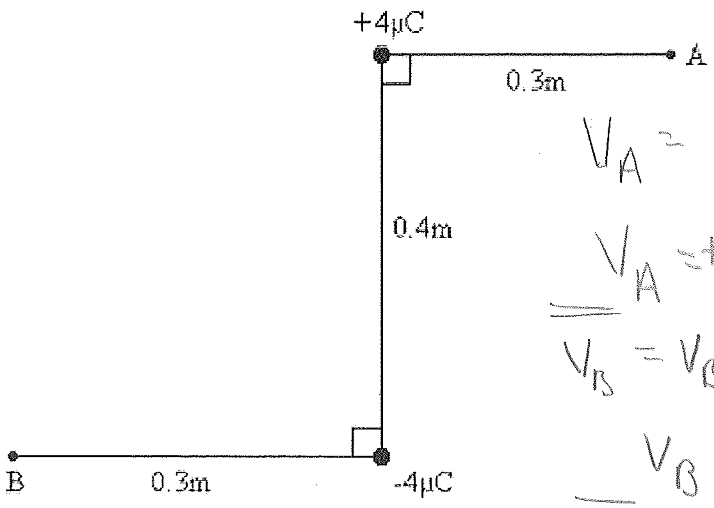
$|\vec{F}_3| < |\vec{F}_1|$ because it is farther away.

A) A ✓
B) B
C) C
D) D

OVER →

24) Two point charges, +4.0 μC and −4.0 μC, are placed as shown in the figure. What is the magnitude of the voltage between points A and B?

See NOTES



$V_A = V_{A_{+4\mu C}} + V_{A_{-4\mu C}} = \frac{k(4\times10^{-6})}{(0.3)} + \frac{k(-4\times10^{-6})}{(0.5)}$

$V_A = +47947\ V$

$V_B = V_{B_{+4\mu C}} + V_{B_{-4\mu C}} = \frac{k(4\times10^{-6})}{(0.5)} + \frac{k(-4\times10^{-6})}{(0.3)}$

$V_B = -47947\ V$

$\Delta V = V_A - V_B = 95893$ volts

A) voltage must be written as a vector.
B) 96 kV ✓
C) 0 kV
D) 48 kV

25) The direction of the electric field halfway between an electron and a proton is ________________.

✓ A) directed toward the electron.
B) perpendicular to the line from the electron to the proton
C) undefined since the electric field is zero.
D) directed toward the proton.

Out of "+"
In to "−"

26) A perfect Carnot engine operates between 350 K and 600 K. The engine delivers 10 kJ of work in each cycle. How much heat is extracted from the 600 K reservoir in one cycle? SEE below

A) 21 kJ
B) 24 kJ ✓
C) 17 kJ
D) 27 kJ
E) 34 kJ

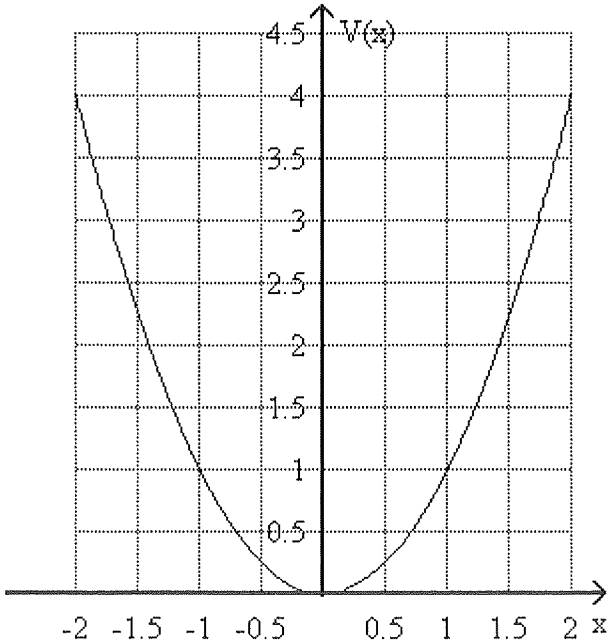
27) Two charged objects are separated by a distance d. The first charge is larger in magnitude than the second charge. Which of the following statements must be true?

A) The first charge exerts a larger force on the second charge.
B) The second charge exerts a larger force on the first charge.
C) The charges exert forces on each other equal in magnitude and opposite in direction. ✓
D) The charges exert forces on each other equal in magnitude and pointing in the same direction.

See NOTES

OVER →

28) The figure shows the variations of the voltage (in arbitrary units) as a function of the position x (also in arbitrary units). Which of the choices below correctly describes the orientation of the electric field along the x axis?



$\vec{E} = -\nabla V$

in 1-d this becomes:

$\vec{E} = -\left[\frac{dV}{dx}\right]\hat{i}$

opposite direction

Slope of tangent line

A) E is in the $+\hat{i}$ direction from x = -2 to x = 0, and in the $-\hat{i}$ direction from x= 0 to x= 2
B) E is negative from x = -2 to x = 2.
C) E is in the $-\hat{i}$ direction from x = -2 to x = 0, and in the $+\hat{i}$ direction from x= 0 to x= 2.
D) E is positive from x = -2 to x = 2

29) A certain engine extracts 1300 J (Q_H) of heat from a hot temperature reservoir and discharges 700 J (Q_L) of heat to a cold temperature reservoir. What is the efficiency of this engine?

$Q_H = W + Q_L$

$\therefore W = Q_H - Q_L = 600$

$\varepsilon = W/Q_H = 0.46$

A) 13% B) 27% C) 46% D) 54% E) 86%

30) A region of space has an electric field $\mathbf{E} = 2x\,\hat{\mathbf{i}} - 4\hat{\mathbf{j}}$. The voltage at the origin is zero. Which of the following is the correct expression for V(x,y,z)?

See below.

A) 0
B) 2x – 4
C) $-x^2 + 4y$
D) More information is needed

31) A region of space has an electric field $\mathbf{E} = 2x\,\hat{\mathbf{i}} - 4\hat{\mathbf{j}}$. What work is done by the electric force if a charge of 5 C is moved from the origin to the point x=2, y=4 along the path given by $y = x^2$? ($\mathbf{dS} = dx\,\hat{\mathbf{i}} + dy\,\hat{\mathbf{j}} + dz\,\hat{\mathbf{k}}$)

A) -12 joules
B) 60 joules
C) - 60 joules
D) 12 joules

Hard way:
$\vec{F} = q\vec{E}$
$W = \int \vec{F}\cdot d\vec{s}$
Like we did 1st Semester. ☺

Easier way: This is the SAME $\vec{E}$ as in the previous question!

$\therefore V(x,y,z) = -x^2 + 4y$
$V(2,4,0) = -4 + 16 = 12$
$V(0,0,0) = 0$

$\Delta V = V(2,4,0) - V(0,0,0) = +12$
$PE = q\Delta V = 5(12) = \boxed{+60\text{ J}}$

1.] See diagram on formula sheet.

$$\varepsilon = 1 - \frac{300}{700} = 0.57 = \frac{W}{Q_H}$$

$$\therefore W = 0.57 Q_H = 0.57(60\,kJ) = 34.2\,kJ$$

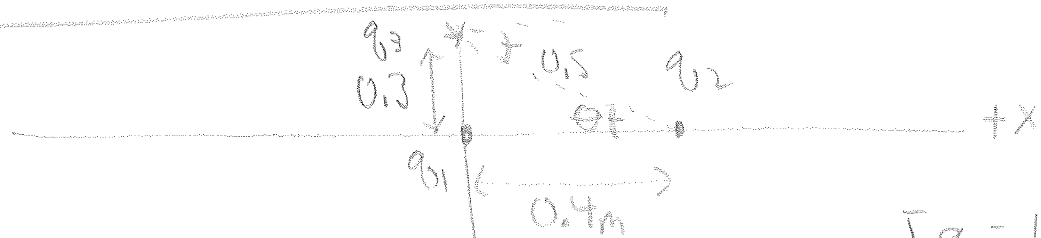
$$Q_H = W + Q_L$$

$$\therefore Q_L = Q_H - W = 60 - 34.2 = \boxed{25.8\,kJ}$$

4.] From diagram on formula sheet (+ an understanding)

$$\varepsilon = \frac{get}{pay} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_L} \underset{CARNOT}{\Longrightarrow} \frac{T_H}{T_H - T_L} = \frac{293}{293-273} = \boxed{14.7}$$

16.]



$q_1 = 10\,\mu C$
$q_2 = 20\,\mu C$
$q_3 = -1.6 \times 10^{-19}\,C$

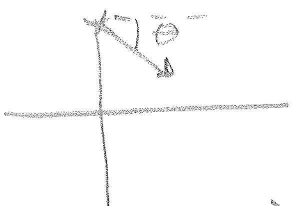
$$|\vec{F}_{q_3 q_1}| = \frac{k|q_3 q_1|}{(0.3)^2} = 1.598 \times 10^{-13}$$

$$\vec{F}_{q_3 q_1} = -1.598 \times 10^{-13}\,\hat{j}$$

opposites attract

$$|\vec{F}_{q_3 q_2}| = \frac{k|q_3 q_2|}{(0.5)^2} = 1.151 \times 10^{-13}$$

$$\theta = \operatorname{Arctan}\left(\frac{0.3}{0.4}\right) = 36.87°$$



$$\vec{F}_{q_3 q_2} = +1.151 \times 10^{-13} \cos(36.87)\,\hat{i} - 1.151 \times 10^{-13} \sin(36.87)\,\hat{j}$$

$$\vec{F}_{TOTAL} = \vec{F}_{q_3 q_1} + \vec{F}_{q_3 q_2} = 9.21 \times 10^{-14}\,\hat{i} - 2.29 \times 10^{-13}\,\hat{j}$$

$$|\vec{F}_{TOTAL}| = \boxed{2.47 \times 10^{-13}}$$

22) See diagram on formula sheet

$$\varepsilon = \frac{Q_L}{W} = \frac{Q_L}{Q_H - Q_L} \underset{\text{CARNOT}}{\Longrightarrow} \frac{T_L}{T_H - T_L} = \frac{275}{295-275} = 13.75$$

$$\therefore W = \frac{Q_L}{13.75} = \frac{24.7 \times 10^3}{13.75}\ \text{J/s} = \boxed{1796\ \text{J/s}}\ (1.8\ \text{kW})$$

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26) $$\varepsilon = 1 - \frac{T_L}{T_H} = 1 - \frac{350}{600} = 0.42 = \frac{W}{Q_H}$$

$$\therefore Q_H = \frac{W}{0.42} = \frac{10\ \text{KJ}}{0.42} = \boxed{23.8\ \text{KJ}}$$

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30) This is an "A" question ☺

$$\vec{E} = -\nabla V(x,y,z) = 2x\hat{i} - 4\hat{j}$$

$$E_x = 2x = -\frac{\partial}{\partial x}V$$

$$\therefore V = -\frac{2x^2}{2} + \text{Constant} = -x^2 + \text{Constant}$$

$$E_y = -4 = -\frac{\partial}{\partial y}V$$

$$\therefore V = 4y + \text{Constant}$$

So we see that $V(x,y,z) = -x^2 + 4y + \text{Constant}$ is consistent.

Given that $V(0,0,0) = 0$

$$\therefore \text{Constant} = 0$$

☺ $$\boxed{V(x,y,z) = -x^2 + 4y}$$