TH 1 S2026 Answer key

Restroom breaks are NOT allowed during the test. If you need one, take it before starting the test.

Internet access, External contact, and Phone Use are NOT allowed.

Only a calculator is allowed for calculations.

Turn off your cell phone. Everything you write must be your own work.

PHYS 202 Spring 2026 Test #1 Equations Sheet

| | | | | |
|---|---|---|---|---|
| $v = v_0 + at$ | $x = \bar{v}\,t$<br>$x = \frac{1}{2}(v + v_0)t$ | $x = v_0 t + \frac{1}{2}at^2$ | $v^2 = v_0{}^2 + 2ax$ | $\vec{F} = m\vec{a}$<br>$\vec{E} = \frac{\vec{F}}{q}$ |

$T_F = \frac{9}{5}T_C + 32$ $T_K = T_C + 273$ $\Delta T_F = \frac{9}{5}\Delta T_C$ $\Delta T_K = \Delta T_C$

$\Delta L = \alpha L_0 \Delta T$ $\Delta A = 2\alpha A_0 \Delta T$ $\Delta V = \beta V_0 \Delta T$ $\beta = 3\alpha$, for solids

$\alpha_{steel} = \alpha_{concrete} = 12\text{x}10^{-6}(C^o)^{-1}$, $\alpha_{aluminum} = 23\text{x}10^{-6}(C^o)^{-1}$, $\alpha_{copper} = 17\text{x}10^{-6}(C^o)^{-1}$.
Volume coefficient of expansion of radiator coolant = $\beta = 390 \times 10^{-6} (C^o)^{-1}$.

$Q = mc\Delta T$ $Q = mL$
(Specific heat of water = 4186 J/(kg.K), Specific heat of ice = 2000 J/(kg.K), Latent heat of fusion of ice = $33.5 \times 10^4$ J/kg)

Work = Force x Distance Power = Work/Time

First Law of thermodynamics: $\Delta U = Q - W$. Work = W= $P.\Delta V$

Work done by a gas: $W = P\cdot\Delta V$ (Isobaric process) $W = nRT\ln\frac{V_f}{V_i}$ (Isothermal process)

Area of a rectangle = length x width, Area of a triangle = $\frac{1}{2}$ x base x height

Heat engines, refrigerators, and heat pumps: Coefficient of performance, $COP = \frac{Q}{W}$.

Entropy, *S*. $\Delta S = \frac{Q}{T}$.

Coulomb's law is given by: $F = k\frac{|Q_1||Q_2|}{r^2}$. Coulomb's constant = k = $9 \times 10^9$ (SI)

PHYS 202 Spring 2026 Test #1 Name: Key

$T_F = \frac{9}{5}T_C + 32$ $T_K = T_C + 273$ $\Delta T_F = \frac{9}{5}\Delta T_C$ $\Delta T_K = \Delta T_C$

A. Select the correct answer for the following multiple-choice questions and write your answer in the line next to the question number.

C 1. Express the temperature 32°F in the K unit?

a. 254 b. 258 c. 273 d. 292 e. 328

d 2. What is the difference in F° of the two temperatures, -15°C and 9°C?

a. 4 b. 6 c. 9 d. 43 e. 75

$\Delta T_C = 24°$

$\Delta T_F = \frac{9}{5} \times 24 = 43.2$

d 3. What is the thermometric property of a heat sensing remote thermometer?

a. Length of a liquid column b. Volume of gas c. Pressure of a gas

d. Infrared radiation e. Ultraviolet radiation f. Resistance

a 4. The first law of thermodynamics is,

a. The law of conservation of energy.

b. Heat flows spontaneously from a substance at a higher temperature to a substance at a lower temperature.

c. Heat flows spontaneously from a substance at a lower temperature to a substance at higher temperature.

d. If two systems individually in thermal equilibrium with a third system, then the two systems are in thermal equilibrium with each other.

e. It is not possible to lower the temperature of any system to absolute zero in a finite number of steps.

e 5. In thermodynamics the collection of objects upon which attention is being focused is called the ***system,*** while everything else in the environment is called the ***surroundings.*** What is the system for an automobile engine?

a. Engine b. Radiator c. Wheels d. Body e. burning gasoline/air mixture

c 6. Conductors have free______________.

a. Protons b. Neutrons c. Electrons d. Nucleons e. Atoms

A 7. An object is charged by contact using a positively charged rod. What type is the charge on the charged object?

B 8. An object is charged by induction using a positively charged rod. What type is the charge on the charged object?

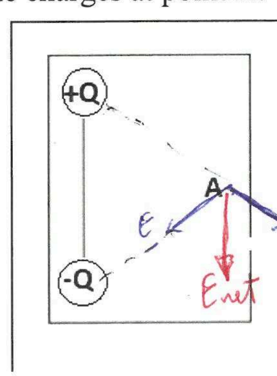
Answers for 8 -9: A. Positive B. Negative C. No charge

9. Two charges –Q and +Q with equal magnitudes are located as shown below. Point A is at equal distance from the charges. Show the electric field by each of the charges at point A.

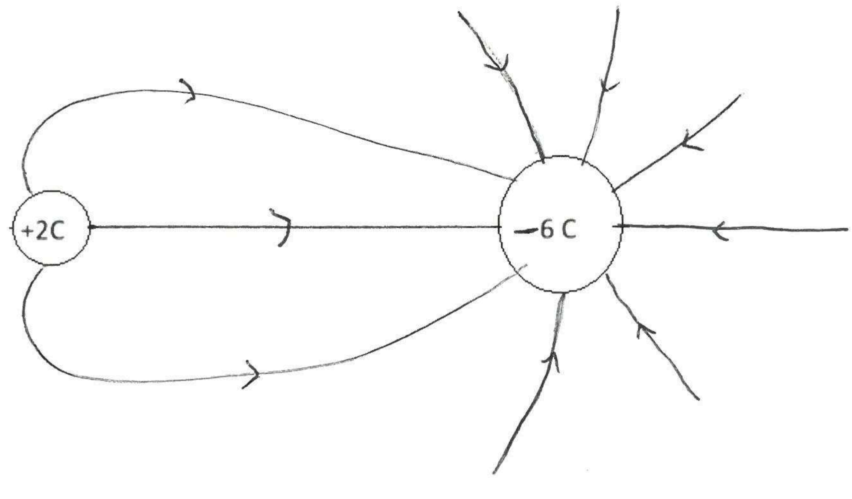
A 10. What is the direction of the net electric field at A?

A. Vertical and down B. Vertical and up

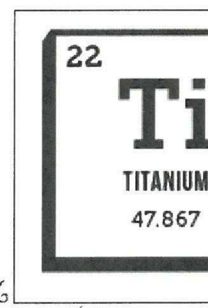
C. Horizontal and to the right D. Horizontal and to the left



B. Sketch the electric field lines for the following two charges, +2C and – 6 C, nearby:




C. How many coulombs of positive charge are there in 2.5 kg of titanium?
($q_p$= +1.6 x $10^{-19}$C, $N_A$= 6.022 x $10^{23}$)




$\# \text{ of moles} = \frac{2.5\times1000}{47.867} = 52.228$

$\# \text{ of atoms} = 52.228 \times 6.022\times10^{23} = 3.145\times10^{25}$

$\# \text{ of protons} = 3.145\times10^{25} \times 22 = 6.919\times10^{26}$

$\text{charge} = 6.919\times10^{26} \times 1.6\times10^{-19}\,C = 11.07\times10^{26}\times10^{-19}\,C$

$\text{Charge} = 1.1\times10^{8}\,C$

Volume of a sphere (of radius $R$) = $V_{sph} = \frac{4}{3}\pi R^3$

Volume of a cylinder (of radius $r$ and height $h$) = $V_{cyl} = \pi r^2 h$

D. A Pyrex round (radius, R = 10 cm) bottom flask with a cylindrical (base radius, r = 2 mm) stem is used to measure the volume coefficient of expansion of a fluid. The fluid is filled to the brim of the spherical top as shown (Fig. a) at a temperature of 23$^0$C. When the fluid is heated to 77$^0$C, it rises to a height, h = 6.5 cm. What is the volume coefficient of expansion of the fluid? (Pyrex has a negligible thermal expansion)

$V_0 = \frac{4}{3}\pi R^3 = \frac{4}{3}\times\pi\times(10^3) = 4189\ cm^3$

$\Delta V = \pi r^2 h = \pi\times(0.2)^2\times6.5 = 0.8168\ cm^3$

$\Delta T = 77-23 = 54\ C^0$

$\Delta V = \beta V_0 \Delta T \rightarrow \beta = \frac{\Delta V}{V_0\,\Delta T} = \frac{0.8168}{4189\times54} = 3.61\times10^{-6}$

$\beta = 3.61\times10^{-6}\ [C^0]^{-1}$

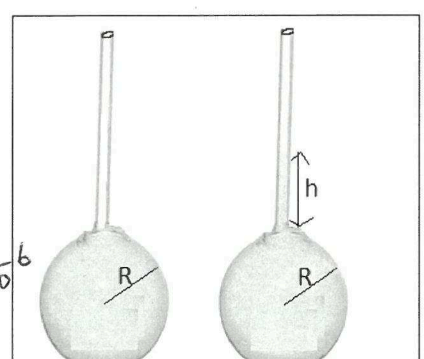
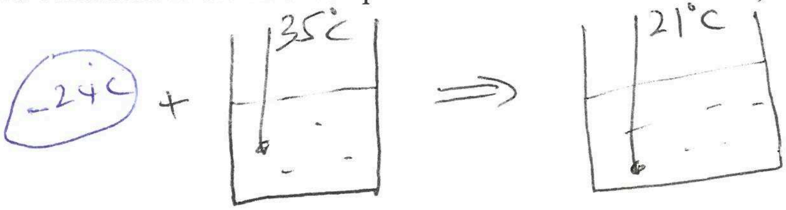


Fig. a Fig. b

E. $Q = mc\Delta T$ $\quad Q = mL$

Specific heat of water = 4186 J/(kg.K), Specific heat of ice = 2000 J/(kg.K), and Latent heat of fusion of ice = $3.35 \times 10^5$ J/kg.

10 An ice cube of unknown mass and at -24$^0$C is placed in 0.39 kg of 35$^0$C water in a very well-insulated container. If the final temperature of the mixture is 21$^0$C, determine the mass of the ice cube?




Heat gain by ice = Heat loss by water

$mc\Delta T + mL + mc\Delta T = mc\Delta T$

$m_i \times 2000 \times (0-(-24)) + m_i \times 3.35\times10^5 + m_i \times 4186 \times (21-0) = m_w \times 4186 \times (35-21)$

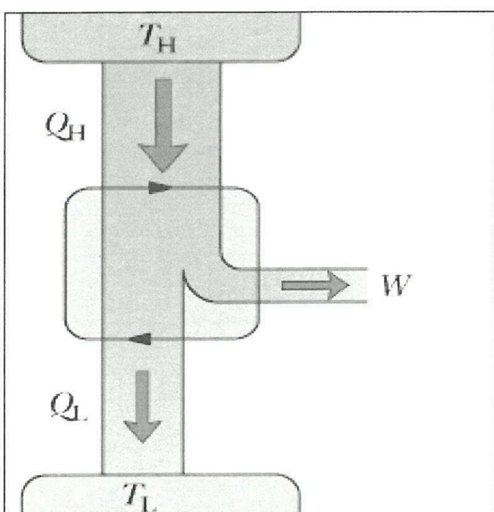
$m_i[2000\times24 + 3.35\times10^5 + 4186\times21] = 0.39\times4186\times14$

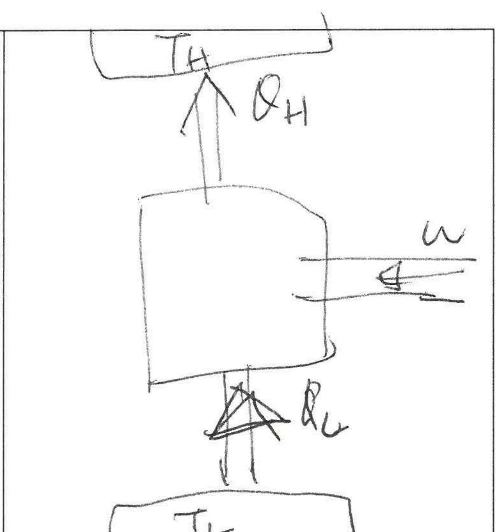
$m_i[48000 + 3.35\times10^5 + 87906] = 22855.56$

$m_i = \frac{22855.56}{470906} = 0.0485\ \text{kg}$

$M_i = 0.0485\ \text{kg} = 48.5\ \text{g}$

6 F. Schematic diagram for a heat engine is shown below. Sketch a similar diagram for a refrigerator inside the empty box below. Also write an expression involving $Q_H$, $Q_L$, and $W$.




| Heat Engine | Refrigerator |
|---|---|
| Expression involving $Q_H$, $Q_L$, and $W$. $Q_H = Q_L + W$ | |

G. Coulomb's law is given by: $F = k\frac{|Q_1||Q_2|}{r^2}$ Coulomb's constant = k = 9 x $10^9$ (SI)

2

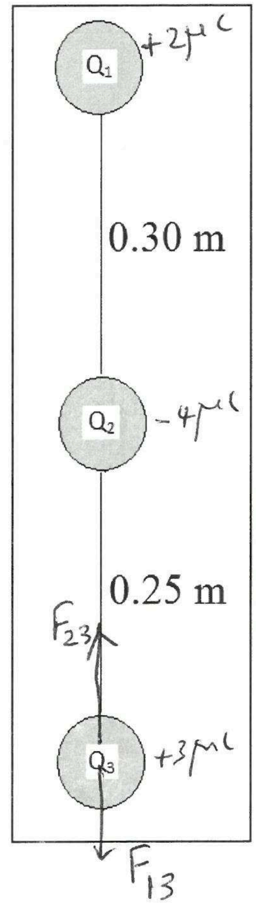
1. Express the SI unit of Coulomb's constant in terms of kg, m, s, and C: $\frac{N.m^2}{C^2} = \frac{kg.m^3}{C^2 s^2}$

6

2. Figure shows 3-point charges that lie along the y axis in a vacuum, with no gravity. $Q_1$ = +2.0 µC, $Q_2$ = −4.0 µC, and $Q_3$ = +3.0 µC.

a. Draw a free-body diagram for the charge $Q_3$.

b. Determine the magnitude and direction of the net electrostatic force on $Q_3$.




$F_{13} = \frac{k|Q_1||Q_3|}{r^2} = \frac{9\times10^9 \times 2\times10^{-6} \times 3\times10^{-6}}{0.55^2} = 0.178\ N \downarrow$

$F_{23} = \frac{k|Q_2||Q_3|}{r^2} = \frac{9\times10^9 \times 4\times10^{-6} \times 3\times10^{-6}}{0.25^2} = 1.728\ N \uparrow$

$F_{net} = 1.55\ N \uparrow$

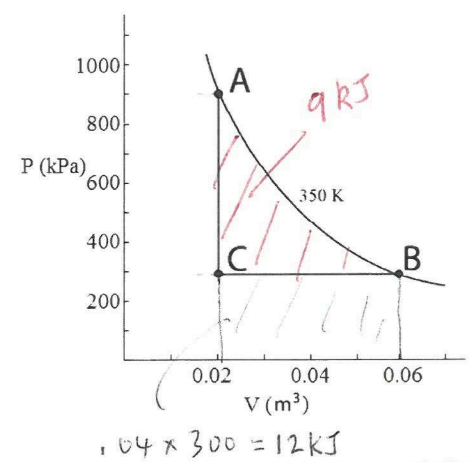
ΔU = Q - W. W= P.ΔV U = (3/2)nRT.

10

H. An ideal gas is taken through the three processes (A→B, B→C, and C→A) shown in the drawing.

1. Name the process **AB** Isothermal and **BC** Isobaric.

2. For the three processes shown in the drawing, fill in the missing entries in the table.




| Process | ΔU | Q | W |
|---|---|---|---|
| A→B | a. 0 | b. 21 kJ | 21 kJ |
| B→C | -19 kJ | d. -31 kJ | c. - 12 kJ |
| C→A | f. 19 kJ | g. 19 kJ | e. 0 |

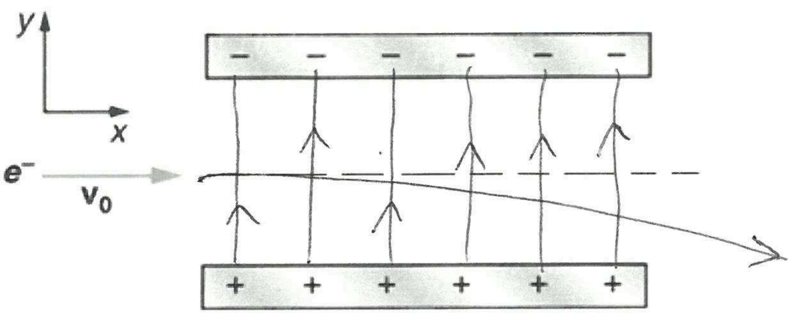
3. Area of the shape ABC= 21 kJ − |−12 kJ|

21 − 12 = 9 kJ

18 I. Figure below shows an electron passing between two charged metal plates that create an electric field of 450 N/C, perpendicular to the electron's original horizontal velocity. The initial speed of the electron is $3.0\times10^6$ m/s, and the horizontal distance it travels in the uniform field is 9.0 cm.

2 (a) Sketch the electric field between the plates.

2 (b) Sketch the path of the electron as it travels between the plates and exits.




(c) How long will it take the electron to cross the plates?

$t = ?$, $x = \bar{v} t$, $x = 9\text{cm} = 9\times10^{-2}$ m

$\bar{v} = 3\times10^{6}$ m/s

2 $t = \frac{x}{v} = \frac{9\times10^{-2}}{3\times10^{6}} = \boxed{3\times10^{-8}\ s}$

(d) What is the vertical acceleration of the electron? [$m_e = 9.11 \times 10^{-31}$kg, $|q_e| = 1.6 \times 10^{-19}$C]

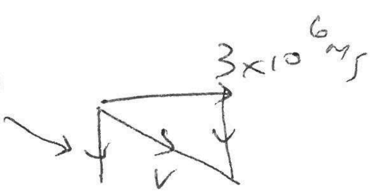
$a_y = ?$ $V_{oy} = 0$, $t = 3\times10^{-8}$ s

2 $a_y = \frac{F_y}{m} = \frac{qE}{m} = \frac{1.6\times10^{-19} \times 450}{9.11\times10^{-31}} = \boxed{7.9\times10^{13}\ m/s^2}$

(e) What is the vertical component of its final velocity?

$V_y = V_{oy} + a_y t$, $V_{oy} = 0$

3 $V_y = 0 + 7.9\times10^{13} \times 3\times10^{-8} = \boxed{2.37\times10^{6}\ m/s}$




(f) What is the magnitude of the total speed of the exiting electron?

3 $V = \sqrt{V_x^2 + V_y^2} = \sqrt{(3\times10^{6})^2 + (2.37\times10^{6})^2}$

$\boxed{V = 3.82\times10^{6}\ m/s}$