13) A sound wave is

a. An electromagnetic wave
b. A transverse wave
c. A longitudinal wave

14) If the frequency of a wave is 170 *Hz*, and the wavelength is 2 *m*, what is the velocity of the wave?

a. 85 *m/s*
b. 340 *m/s*
c. 4 *m/s*
d. 34 *m/s*
e. 1360 *m/s*

15) If a sound source moves in the direction of a stationary observer, the observer hears the sound wave at a greater

a. Velocity
b. Period
c. Wavelength
d. Amplitude
e. Frequency

16) A cylinder is capped by a piston such that it contains a volume of 20 *ml* of an ideal gas at a pressure of 40 *psi*. If the volume is decreased to 10 *ml*, what is the new pressure? Assume the temperature is constant.

$PV = nRT \rightarrow P_1V_1 = P_2V_2$ (constant T)

a. 20 *psi*
b. 80 *psi*
c. 40 *psi*

$$P_2 = P_1 \frac{V_1}{V_2}$$

$$= 40 \text{ psi} \times \frac{20}{10}$$

$$= 80 \text{ psi}$$

17) The temperature of an ideal gas quadruples. How does the root-mean-square speed of the gas molecules of the hotter gas, v'_{rms}, compare to the root-mean-square molecular speed of the cooler gas, v_{rms}?

(a.) $v'_{rms} = 2v_{rms}$
b. $v'_{rms} = v_{rms}$
c. $v'_{rms} = 16v_{rms}$
d. $v'_{rms} = 4v_{rms}$
e. $v'_{rms} = 0.5v_{rms}$

$\langle K \rangle_{tr} = \frac{1}{2} m v_{rms}^2 = \frac{3}{2} kT \Rightarrow v_{rms} \propto \sqrt{T}$

If $T \to 4T$,

$v_{rms} \to 2 v_{rms}$

18) A piece of metal with coefficient of expansion $\alpha = 16 \times 10^{-6} K^{-1}$ at $273K$ has length 1 m. By how much does the length change if it is heated to 900 K?

a. 1 mm
(b.) 10 mm
c. 100 mm

$\Delta L = \alpha L \Delta T$

$= 16 \times 10^{-6} K^{-1} \times 1m \times (900 - 273) K$

$= 0.01 m = 10 mm$

19) A ring of metal with a circular hole in the middle is heated. As a result of heating, the diameter of the hole

a. Decreases
b. Stays the same
(c.) Increases

20) An observer measures the loudness of a speaker to be 50 dB. What would be the loudness of 100 identical speakers together?

a. 70 dB
b. 250 dB
c. 55 dB
d. 150 dB
e. 500 dB

THESE PROBLEMS NOT ON EXAM 3

The following question is by itself.

20. There is a cubic box of size a. When its temperature is raised from 230 K to 340 K, its surface area increases by 2.2 %. What is the % increase of its volume in the same situation?

a. 1.5 %
(b.) 3.3 %
c. 2.2 %
d. 2.7 %
e. 4.4 %

$$\frac{\Delta V}{V} = 3\frac{\Delta L}{L}$$

$$\frac{\Delta A}{A} = 2\frac{\Delta L}{L}$$

$$\Rightarrow \frac{\Delta V}{V} = \frac{3}{2}\frac{\Delta A}{A}$$

$$= \frac{3}{2} \times 2.2\% = 3.3\%$$

The following question is by itself

21. An ideal gas thermometer is a small rigid container of volume 120 cm^3 containing 0.03 moles of ideal gas. From its pressure the temperature is measured. The thermometer is dipped in a liquid and, after thermal equilibrium is reached, the pressure of the thermometer is 293 kPa. What is the temperature of the liquid?

a. 390 K
(b.) 141 K
c. 297 K
d. 401K
e. 323 K

$$PV = nRT \Rightarrow T = \frac{PV}{nR}$$

$$= \frac{293\ kPa \times 120\ cm^3}{0.03 \times 8.314\ J\ K^{-1}}$$

$$= 141\ K$$

The next two questions refer to the same situation.

A tank of volume 1.3 m^3 contains an ideal gas consisting of a chemical species A, whose pressure is P = 490 kPa and temperature T = 320 K.

22. How many molecules are there in the tank?

a. 0.31×10^{24}
b. 1.44×10^{24}
c. 1.12×10^{25}
(d.) 1.44×10^{26}
e. 0.31×10^{26}

$$PV = NkT \Rightarrow N = \frac{PV}{kT}$$

$$= \frac{490\ kPa \times 1.3\ m^3}{1.38 \times 10^{-23}\ J\ K^{-1} \times 320\ K}$$

$$= 1.44 \times 10^{26}$$

23. The root-mean-square velocity of the gas molecules is 257 m/s. What is the molecular mass of chemical species A? Express your answer in unit of unified atomic mass u. 1 u = 1.66×10^{-27} kg.

a. 163 u.
(b.) 121 u.
c. 49 u.
d. 82 u.
e. 103 u.

$$\langle K_{tr} \rangle = \frac{1}{2} m v_{rms}^2 = \frac{3}{2} kT$$

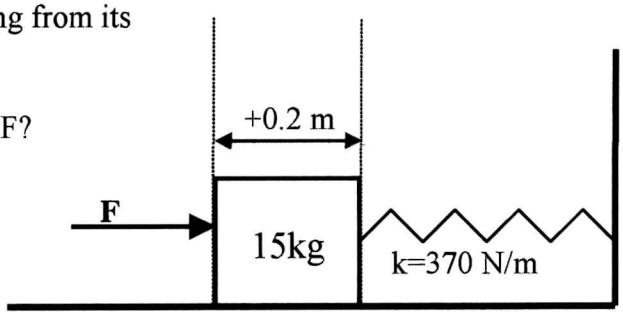
$$\Rightarrow m = 3\frac{kT}{v_{rms}^2} = 3\frac{1.38 \times 10^{-23}\ J\ K^{-1} \times 320\ K}{(257\ m/s)^2}$$

$$= 2.0 \times 10^{-25}\ kg = 120.5\ u$$

Check to make sure that you bubbled in all of your answers. Did you bubble in your name, network id and exam version?

The following three questions concern the same physical situation:

A block of mass 15 kg is resting on a horizontal frictionless surface and is attached to a spring with a force constant k = 370 N/m. A force of **F** is applied to the block in the x-direction, thereby compressing the spring from its equilibrium length by 0.2 m.



21. What is the magnitude of the force F?

a. 33 N
b. 54 N
c. 74 N

22. The force is removed and the block starts to oscillate. How long does it take to complete one oscillation?

a. 1.26 sec
b. 1.71 sec
c. 2.51 sec
d. 3.69 sec
e. 4.76 sec

23. What is the speed of the block when it reaches the equilibrium position for the first time?

a. 0.24 m/s
b. 0.73 m/s
c. 0.99 m/s
d. 1.64 m/s
e. 2.28 m/s

---

24. A bar of copper (Cu) with length 200.01 m and a bar of aluminum (Al) with length 200.00 m are sitting at room temperature, T=25°C. At what temperature will the two have the same length? $\alpha_{Cu} = 1.60\times10^{-7}\ K^{-1}$ $\alpha_{Al} = 2.25\times10^{-7}\ K^{-1}$.

(a) 794 °C
b. 1203 °C
c. 2011 °C
d. 3094 °C
e. 3455 °C

$\Delta L = \alpha L \Delta T$

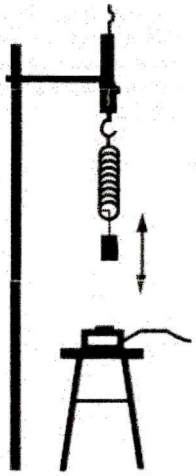
$L_1 + \Delta L_1 = L_2 + \Delta L_2$

$L_1 - L_2 = \Delta L_2 - \Delta L_1 = (\alpha_2 L_2 - \alpha_1 L_1)(T - T_0)$

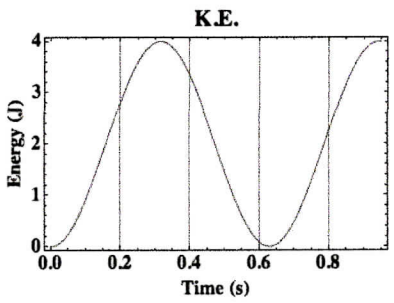
$L_1 - L_2 = 0.01\ m$ $\quad \alpha_2 L_2 - \alpha_1 L_1 = 0.000013$ $\quad T = 794°C$ $\quad T_0 = 25°C$

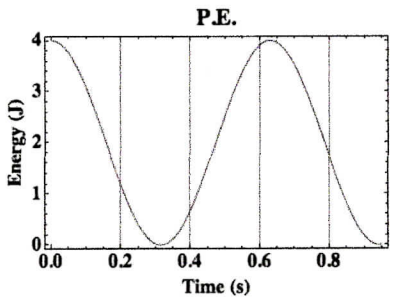
Did you bubble in your name, exam version, and network ID?
Check to make sure you have bubbled in all your answers.

11. In an experiment in lab shown in figure, you studied the motion of a mass M hanging from a vertical spring with spring constant k. The mass was initially at its equilibrium position. It was then lifted up by a small distance and released. It afterward starts to oscillate vertically. Assuming the period of oscillation is T and frequency of the oscillation is f. Which of the following individual potential energy (P.E.) and kinetic energy (K.E.) vs. time graphs is correct?

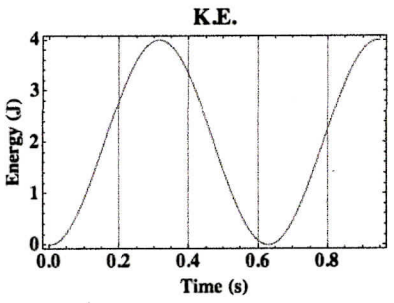


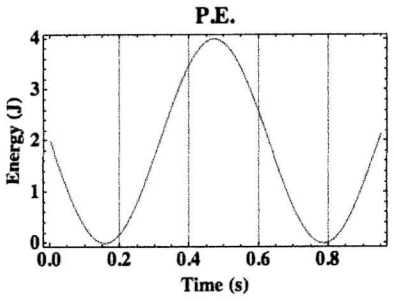
(a)



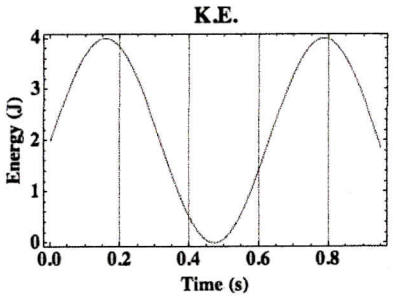


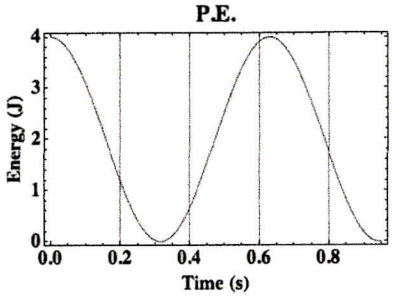
(b)





(c)

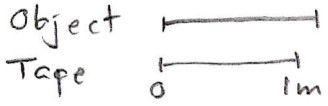




12. Consider two containers with the same volume, each containing the same mass of gas. One is filled with molecular oxygen (each molecule has an atomic weight of about 32), the other with molecular nitrogen (each molecule has an atomic weight of about 28). Which has the larger number density?

a. oxygen
b. nitrogen
c. not enough information given

1. A steel tape measure is marked in such a way that it gives accurate length measurements at 20° C. Suppose this tape measure is used on a cold day when the temperature is 0° C. Assuming that the object you are measuring has a much smaller linear expansion coefficient than steel, the length measured with this tape measure will be

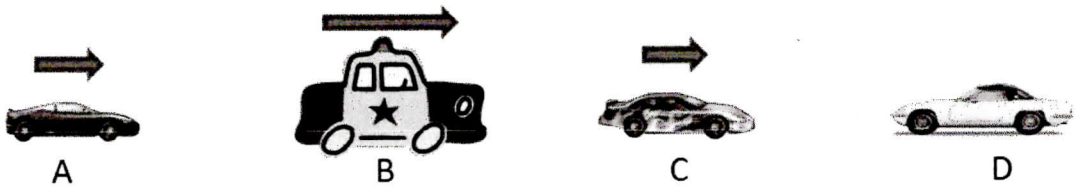


(a) too long
b. too short
c. accurate

2. A washer has a hole in the middle of it. As the washer is heated, the radius of the hole decreases.

a. true
(b.) false

3. Four vehicles are moving as shown below.



Each has its own driver. Vehicles A, B, and C are moving in the same direction (to the right) but vehicle B is moving faster than vehicles A and C. Vehicle D is not moving. Vehicle B is a police car and its siren is producing a sound of a certain frequency f_B as heard by the driver in vehicle B. What is the relationship between f_A, f_B, f_C and f_D, the frequencies of the siren heard by drivers of the respective vehicles?

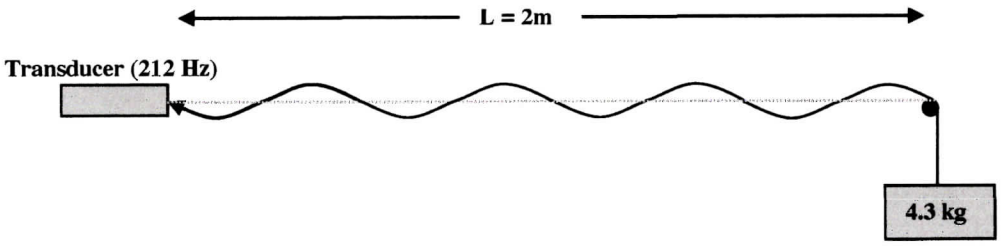
a. $f_D > f_A > f_B > f_C$
b. $f_D > f_C = f_B > f_A$
c. $f_A > f_C > f_B > f_D$
d. $f_D > f_B > f_C > f_A$
e. $f_D > f_C > f_B > f_A$

4. A siren, 10 m away, produces a sound of loudness 30 dB. Now, two sirens identical to this are placed 5 m away from you. What is the loudness that you hear?

a. 31 dB
b. 33 dB
c. 39 dB

The next two questions pertain to the same situation.

One end of a string with length L = 2 m and mass density μ is attached to a weight with mass 4.3 kg. The other end of the string is fixed to a transducer that vibrates at a frequency of 212 Hz. A standing wave results, with the wavelength as shown in the snapshot below



5. What is the mass of the string?

a. 2.27 g
b. 3.75 g
c. 5.56 g
d. 7.50 g
e. 12.1 g

6. If the mass of the weight were quadrupled (i.e. increased to 17.2 kg), what would happen to the number of wavelengths in the standing wave?

a. It would quadruple
b. It would double
c. It would not change
d. It would decrease by a factor of two
e. It would decrease by a factor of four

---

7. In a container of volume V = 0.5 m^3 is 0.4 kg of an ideal gas. Its pressure is P = 1.25 × 10^5 Pa at room temperature (23 °C). What is the molecular mass M of the molecules making the gas?

$PV = NkT \Rightarrow N = \frac{PV}{kT} = \frac{1.25\times10^5\ Pa \times 0.5\ m^3}{1.38\times10^{-23}\ J\,K^{-1} \times (273+23)\ K}$

$= 1.53\times10^{25}$

$M = \frac{0.4\ kg}{1.53\times10^{25}} = 2.62\times10^{-26} = 15.7\ u$

$(1\ u = 1.66\times10^{-27}\ kg)$

a. M = 15.4 amu
b. M = 30.9 amu
c. M = 33.5 amu
d. M = 41.1 amu
e. M = 61.6 amu

24) At what speed, v_s, must a car drive towards a stationary observer so that the frequency heard by the observer, f_o, is twice that emitted by the source, f_s, i.e. $f_o = 2f_s$? The speed of sound is $v = 330\ m/s$.

a. $v_s = 187\ m/s$
b. $v_s = 165\ m/s$
c. $v_s = 212\ m/s$
d. $v_s = 375\ m/s$
e. $v_s = 100\ m/s$

25) You heat a metallic strip from $275\ K$ to $1248\ K$. If at $275\ K$ its length is $1.58\ m$ and the coefficient of linear expansion is $\alpha = 19 \times 10^{-6}\ K^{-1}$, what is the length of the strip at $1248\ K$?

a. $l = 2.37\ m$
(b.) $l = 1.61\ m$
c. $l = 0.79\ m$

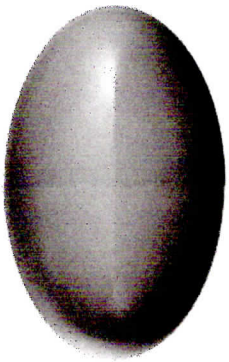
$$\Delta L = \alpha L \Delta T$$
$$= 19 \times 10^{-6}\ K^{-1} \times 1.58\ m \times (1248 - 275)\ K$$
$$= 0.03\ m$$
$$L' = L + \Delta L = 1.58\ m + 0.03\ m = 1.61\ m$$

26) We use a piston to compress $94\ ml$ of a gas at a pressure of $53\ Pa$ to a new volume of $19\ ml$ at constant temperature. What is the new pressure of the gas?

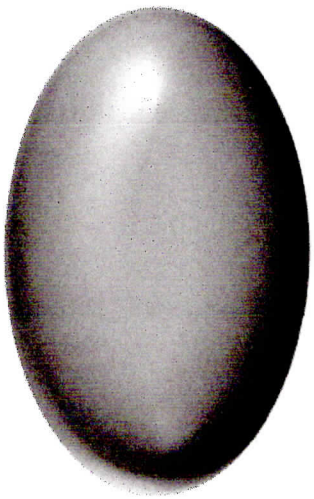
a. $P = 167\ Pa$
b. $P = 148\ Pa$
c. $P = 19\ Pa$
d. $P = 33.7\ Pa$
(e.) $P = 262\ Pa$

$$PV = nRT \Rightarrow P_1 V_1 = P_2 V_2 \quad \text{constant } T$$
$$P_2 = P_1 \frac{V_1}{V_2}$$
$$= 53\ Pa \times \frac{94}{19}$$
$$= 262\ Pa$$

The next two questions pertain to the situation described below.



Balloon at T_1



Balloon at T_2

You fill a balloon with $V_1 = 0.00159\ m^3$ of argon gas (*molar mass = 40 amu*) at $T_1 = 20^oC$. You heat the gas in the balloon, keeping the pressure constant.

17) At $T_2 = 31.5^oC$, what is the volume of the gas in the balloon?

a. $V_2 = 0.0025\ m^3$
b. $V_2 = 0.00165\ m^3$
c. $V_2 = 0.00153\ m^3$

$PV = nRT \Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2}$ constant P

$V_2 = V_1 \frac{T_2}{T_1}$

$= 0.00159\ m^3 \times \frac{(273 + 31.5)}{(273 + 20)} = 0.00165\ m^3$

18) At $T_2 = 31.5^oC$, what is the RMS speed, v_{RMS}, of the argon atoms in the balloon? (*1 amu = 1.66x10^{-27} kg*)

a. $v_{RMS} = 140\ m/s$
b. $v_{RMS} = 308\ m/s$
c. $v_{RMS} = 436\ m/s$

$\langle K \rangle = \frac{1}{2} m v_{rms}^2 = \frac{3}{2} kT$

$v_{rms} = \sqrt{\frac{3kT}{m}}$

$= \sqrt{\frac{3 \times 1.38 \times 10^{-23}\ J\ K^{-1} \times (273 + 31.5) K}{40 \times 1.66 \times 10^{-27}\ kg}}$

$= 436\ m/s$

11) Race car tires operate at high temperatures. At $T_{cool} = 20^oC$ the tires are filled with $P_{cool} = 25.9\ PSI$, and put on the race car. After 5 laps, the tires reach $T_{hot} = 66.5^oC$. What is the pressure in the tires (assume the volume of the tires is constant)?

a. $P_{hot} = 22.4\ PSI$
b. $P_{hot} = 86.1\ PSI$
c. $P_{hot} = 30\ PSI$

$PV = nRT \Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2}$ constant V

$P_2 = P_1 \frac{T_2}{T_1}$

$= 25.9\ psi \times \frac{(273 + 66.5)}{(273 + 20)}$

$= 30\ psi$

12) A liquid has a density at $289\ K$ of $955\ kg/m^3$. Its (volume) thermal expansion coefficient is $1.05x10^{-3}/K$. What is its density at $316\ K$?

a. $983\ kg/m^3$
b. $1050\ kg/m^3$
c. $929\ kg/m^3$
d. $1020\ kg/m^3$
e. $845\ kg/m^3$

$\frac{\Delta V}{V} = \beta \Delta T$

$= 1.05 \times 10^{-3}\ K^{-1} \times (316 - 289)\ K$

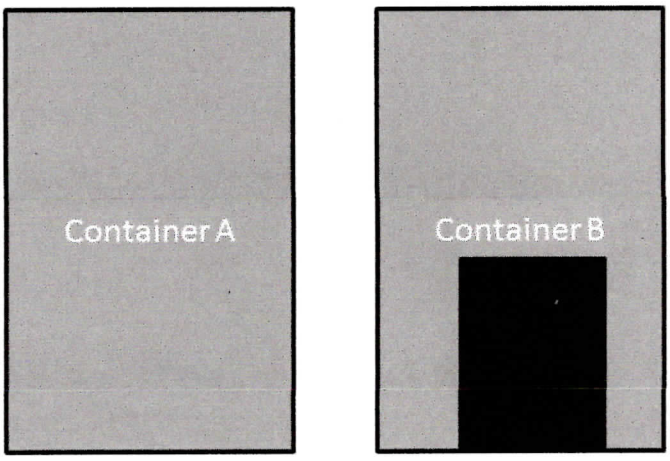
$= 0.028$

because $\frac{1}{1+\epsilon} \approx 1 - \epsilon$ small ϵ

$\rho' = \frac{M}{V + \Delta V} = \frac{M}{V(1 + \frac{\Delta V}{V})} \approx \frac{M}{V}(1 - \frac{\Delta V}{V}) = 955\ \frac{kg}{m^3}(1 - 0.028)$

$= 928\ kg/m^3$

Consider two identical containers. Container A is filled with water to the top. Container B has a block of iron which sinks to the bottom, but the level of the water is also at the top.

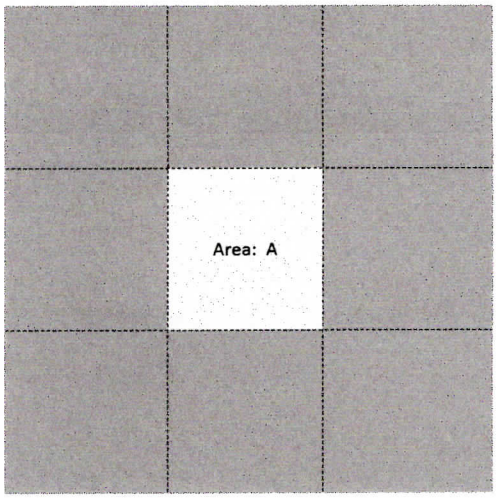


13) Which container weighs more?

a. *Container B*
b. *They both weigh the same*
c. *Container A*

The next two questions pertain to the situation described below.

Consider this plate of aluminum at $T_1 = 20^oC$ with a square hole as shown in the diagram. The coefficient of linear thermal expansion is $\alpha = 23.1x10^{-6}\ K^{-1}$.



4) When the plate is heated to $T_2 = 350^o$ the hole will

a. *get smaller*
b. *get larger*
c. *stay the same*

5) If the hole has area $A = 1.5\ cm^2$ at $T_1 = 20^oC$, what is the area of the hole at $T_2 = 350^o$? (hint: The thermal expansion coefficient for an area is $\alpha_A = 2\ \alpha$)

a. $A_{new} = 1.52\ cm^2$
b. $A_{new} = 1.55\ cm^2$
c. $A_{new} = 1.48\ cm^2$

$$\Delta A = 2\alpha A \Delta T$$
$$= 2 \times 23.1 \times 10^{-6}\ K^{-1} \times 1.5\ cm^2 \times (350 - 20)$$
$$= 0.015\ cm^2$$

$$A' = A + \Delta A$$
$$= 1.5\ cm^2 + 0.015\ cm^2$$
$$= 1.515\ cm^2$$