MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A machinist needs to remove a tight fitting pin of material A from a hole in a block made of material B. The machinist heats both the pin and the block to the same high temperature and removes the pin easily. What statement relates the coefficient of thermal expansion of material A to that of material B?
   A) Material B has a greater coefficient of expansion than does material A.
   B) Material A has a greater coefficient of expansion than does material B.
   C) Material B has the same coefficient of expansion as does material A.
   D) The situation is not possible because heating block B will shrink the hole in the material as the material expands with increasing temperature.

2) For a fixed amount of gas, if the absolute temperature of the gas is doubled, what happens to the pressure of the gas?
   A) The pressure of the gas becomes double the original pressure.
   B) The pressure of the gas becomes eight times the original pressure.
   C) The pressure of the gas becomes four times the original pressure.
   D) The answer cannot be determined without volume information.
   E) The pressure of the gas becomes one half the original pressure.

3) The number of molecules in one mole of a substance
   A) depends on the molecular weight of the substance.
   B) depends on the temperature of the substance.
   C) is the same for all substances.
   D) depends on the atomic weight of the substance.
   E) depends on the density of the substance.

4) Which contains more moles of material: 80 grams of helium gas (He, having atomic weight 4.0 g/mol) or 400 grams of argon gas (Ar, having atomic weight 40 g/mol)?
   A) helium
   B) argon
   C) Both contain the same number of moles.

5) If the temperature of a fixed amount of an ideal gas is increased, it NECESSARILY follows that
   A) the pressure of the gas will increase.
   B) the speed of the gas molecules will increase.
   C) the volume of the gas will increase.
   D) All of the above statements are correct.

6) A sample of an ideal gas is slowly compressed to one-half its original volume with no change in pressure. If the original root-mean-square speed (thermal speed) of the gas molecules was \( V \), the new speed is
   A) \( \sqrt{2}V \).
   B) \( V \).
   C) \( V/\sqrt{2} \).
   D) \( 2V \).
   E) \( V/2 \).
7) A container is filled with a mixture of helium (light molecules) and oxygen (heavy molecules) gases. A thermometer in the container reads 22°C. Which gas molecules have the greater average kinetic energy?
   A) The helium molecules do because they are less massive.
   B) The oxygen molecules do because they are more massive.
   C) The helium molecules do because they are monatomic.
   D) The oxygen molecules do because they are diatomic.
   E) It is the same for both of the gases because the temperatures are the same.

8) Suppose that a steel bridge, 1000 m long, was built without any expansion joints and that only one end of the bridge was held fixed. What would the difference in the length of the bridge be between winter and summer, taking a typical winter temperature as 0.00°C, and a typical summer temperature as 40°C? The coefficient of thermal expansion of steel is $10.5 \times 10^{-6} \text{ K}^{-1}$.
   A) 0.11 mm  
   B) 0.42 mm  
   C) 0.42 m  
   D) 0.11 m  
   E) 0.37 cm

9) A glass flask has a volume of 500 mL at a temperature of 20°C. The flask contains 492 mL of mercury at 20°C. The temperature of the mercury and flask is raised until the mercury reaches the 500 mL reference mark. The coefficients of volume expansion of mercury and glass are $18 \times 10^{-5} \text{ K}^{-1}$ and $2.0 \times 10^{-5} \text{ K}^{-1}$, respectively. The temperature at which this occurs is closest to
   A) 122°C.  
   B) 112°C.  
   C) 132°C.  
   D) 102°C.  
   E) 110°C.

10) If we use 67 W of power to heat 148 g of water, how long will it take to raise the temperature of the water from 15°C to 25°C? The specific heat of water is $4190 \text{ J/kg \cdot K}$.
   A) 22 s  
   B) 93 s  
   C) 114 h  
   D) 5.3 s

11) A substance has a melting point of 20°C and a heat of fusion of $3.9 \times 10^4 \text{ J/kg}$. The boiling point is 150°C and the heat of vaporization is $7.8 \times 10^4 \text{ J/kg}$ at a pressure of 1.0 atm. The specific heats for the solid, liquid, and gaseous phases are $600 \text{ J/(kg \cdot K)}$, $1000 \text{ J/(kg \cdot K)}$, and $400 \text{ J/(kg \cdot K)}$, respectively. The quantity of heat required to raise the temperature of 3.80 kg of the substance from -6°C to 128°C, at a pressure of 1.0 atm, is closest to
   A) 560 kJ.  
   B) 210 kJ.  
   C) 620 kJ.  
   D) 770 kJ.  
   E) 470 kJ.

12) If you add 700 kJ of heat to 700 g of water at 70.0°C, how much water is left in the container? The latent heat of vaporization of water is $2.26 \times 10^6 \text{ J/kg}$ and its specific heat is $4190 \text{ J/(kg \cdot K)}$.
   A) 258 g  
   B) 429 g  
   C) 340 g  
   D) 600 g  
   E) none
13) A person pours 330 g of water at 45°C into an 855-g aluminum container with an initial temperature of 10°C. The specific heat of aluminum is 900 J/(kg⋅K) and that of water is 4190 J/(kg⋅K). What is the final temperature of the system, assuming no heat is exchanged with the surroundings?

A) 31°C  B) 28°C  C) 32°C  D) 35°C  E) 33°C

14) What is the steady state rate of heat flow through a pane of glass that is 40.0 cm by 30.0 cm with a thickness of 4.00 mm when the outside temperature of the glass is -10.0°C and its inside temperature is 25.0°C? The thermal conductivity of glass is 0.105 W/(m⋅K), the specific heat of glass is 0.180 cal/(g⋅°C), and 1 cal = 4.190 J.

A) 24.2 W  B) 110 W  C) 18.6 W  D) 47.3 W  E) 3.81 W

15) A blacksmith is flattening a steel plate that measures 10 cm × 15 cm × 1 mm. He has heated the plate to 900 K. If the emissivity of the plate is 0.75, what is the total rate at which it radiates energy? The Stefan-Boltzmann constant is 5.670 × 10⁻⁸ W/m²⋅K⁴. Ignore any heat it receives from the surroundings.

A) 850 W  B) 360 W  C) 760 W  D) 880 W  E) 790 W

16) A sealed 26-m³ tank is filled with 2000 moles of oxygen gas (O₂) at an initial temperature of 270 K. The gas is heated to a final temperature of 460 K. The ATOMIC mass of oxygen is 16.0 g/mol, and the ideal gas constant is R = 8.314 J/mol⋅K = 0.0821 L⋅atm/mol⋅K. The final pressure of the gas is closest to

A) 0.33 MPa.  B) 0.34 MPa.  C) 0.36 MPa.  D) 0.29 MPa.  E) 0.31 MPa.

17) A weather balloon contains 12.0 m³ of hydrogen gas when the balloon is released from a location at which the temperature is 22.0°C and the pressure is 101 kPa. The balloon rises to a location where the temperature is -30.0°C and the pressure is 20.0 kPa. If the balloon is free to expand so that the pressure of the gas inside is equal to the ambient pressure, what is the new volume of the balloon? Assume that in both cases the hydrogen gas is in thermal equilibrium with the outside air.

A) 49.9 m³  B) 2.38 m³  C) 82.6 m³  D) 14.0 m³  E) 4.16 m³

18) A hot air balloon has a volume of 2.00 × 10³ m³ when fully inflated, and the air inside the balloon is always at atmospheric pressure of 1.01 × 10⁵ Pa because of the large opening used to fill the balloon and heat the air inside it. What is the mass of hot air inside the balloon if its temperature is 120°C? The universal gas constant is 8.314 J/mol⋅K. (Assume a molecular weight of 28.8 g/mol for air.)

A) 62.0 kg  B) 5850 kg  C) 1780 kg  D) 203 kg
19) An ideal gas is kept in a rigid container that expands negligibly when heated. The gas
starts at a temperature of 20.0°C, and heat is added to increase its temperature. At what
temperature will its root-mean-square speed (thermal speed) be double its value at
20.0°C?
A) 400°C   B) 313°C   C) 141°C   D) 899°C   E) 40.0°C

20) What is the average translational kinetic energy per molecule of an ideal gas at a
temperature of 300 K? The Boltzmann constant is $1.38 \times 10^{-23}$ J/K.
A) $8.3 \times 10^{-21}$ J
B) $4.1 \times 10^{-21}$ J
C) $6.2 \times 10^{-21}$ J
D) $2.1 \times 10^{-21}$ J
E) $1.7 \times 10^{-21}$ J

21) The root-mean-square speed (thermal speed) of a certain sample of carbon dioxide
molecules, with a molecular weight of 44 g/mol, is 396 m/s. What is the
root-mean-square speed (thermal speed) of water vapor molecules, with a molecular
weight of 18 g/mol, at the same temperature?
A) 619 m/s   B) 253 m/s   C) 421 m/s   D) 506 m/s   E) 396 m/s

22) A cubic box with sides of 20.0 cm contains $2.00 \times 10^{23}$ molecules of helium with a
root-mean-square speed (thermal speed) of 200 m/s. The mass of a helium molecule is
$3.40 \times 10^{-27}$ kg. What is the average pressure exerted by the molecules on the walls of
the container? The Boltzmann constant is $1.38 \times 10^{-23}$ J/K and the ideal gas constant is
$R = 8.314$ J/mol $\cdot$ K = 0.0821 L $\cdot$ atm/mol $\cdot$ K.
A) 2.26   B) 9.10 Pa   C) 1.13   D) 3.39   E) 570 Pa
kPa   kPa   kPa

23) The mean free path of an oxygen molecule is $2.0 \times 10^{-5}$ m, when the gas is at a
pressure of 120 Pa and a temperature of 275 K. The atomic mass of oxygen is 16.0
g/mol, the Boltzmann constant is $1.38 \times 10^{-23}$ J/K, Avogadro's number is $6.02 \times 10^{23}$
molecules/mole, and the ideal gas constant is $J/mol \cdot K = 0.0821$ L $\cdot$ atm/mol $\cdot$ K. The
radius of an oxygen molecule is closest to
A) 0.28   B) 0.22   C) 0.24   D) 0.30   E) 0.26
nm.   nm.   nm.   nm.   nm.

**SHORT ANSWER.** Write the word or phrase that best completes each statement or answers the question.

24) If a certain sample of an ideal gas has a temperature of 109°C and exerts a
pressure of $1.2 \times 10^4$ Pa on the walls of its container, how many gas molecules
are present in each cubic centimeter of volume? The ideal gas constant is 8.314
J/mol $\cdot$ K and Avogadro's number is $6.022 \times 10^{23}$ molecules/mol.
Answer Key
Testname: STUDYE1_PHYS211

1) A  
2) D  
3) C  
4) A  
5) B  
6) C  
7) E  
8) C  
9) A  
10) B  
11) C  
12) B  
13) C  
14) B  
15) A  
16) D  
17) A  
18) C  
19) D  
20) C  
21) A  
22) C  
23) D  

24) $2.3 \times 10^{18}$ molecules