

Key

**Thermodynamics Review**

1) Which of the following could NOT be used to indicate a temperature change? A change in:

- A) color of a metal rod
- B) length of a liquid column
- C) pressure of a gas at constant volume
- D) electrical resistance
- E) mass of one mole of gas at constant pressure

2) A mass  $m$  of helium gas is in a container of constant volume  $V$ . It is initially at pressure  $p$  and absolute (Kelvin) temperature  $T$ . Additional Helium is added, bringing the total mass of helium gas to  $3m$ . After this addition, the temperature is found to be  $2T$ . What is the gas pressure?

- A)  $2/3 p$
- B)  $3/2 p$
- C)  $2 p$
- D)  $3 p$
- E)  $6 p$

3) A gas can be taken from state a to state c by two different reversible processes,  $a \rightarrow c$  or  $a \rightarrow b \rightarrow c$ . During the direct process  $a \rightarrow c$ , 20 J of work are done by the system and 30 J of heat are added to the system. During the process  $a \rightarrow b \rightarrow c$ , 25 J of heat are added to the system. How much work is done by the system during  $a \rightarrow b \rightarrow c$ ?

- A) 5 J
- B) 10 J
- C) 15 J
- D) 20 J
- E) 25 J



4) What temperature change on the Kelvin scale is equivalent to a 10 degree change on the Celsius scale

- A) 283 K
- B) 273 K
- C) 18 K
- D) 10 K
- E) 0 K

5) Which would be the most comfortable temperature for your bath water?

- A)  $0^\circ\text{C}$  (freezing)
- B)  $40^\circ\text{C}$  ( $= -233^\circ\text{C}$ )
- C)  $110^\circ\text{C}$  (boil +  $10^\circ\text{C}$ )
- D)  $310^\circ\text{K}$  ( $= 37^\circ\text{C}$ )
- E)  $560^\circ\text{K}$  ( $= 287^\circ\text{C}$ )

6) When an ideal gas is isothermally compressed

- A) thermal energy flows from the gas to the atmosphere
- B) the temperature of the gas decreases
- C) no thermal energy enters or leaves the gas
- D) the temperature of the gas increases
- E) thermal energy flows from the surroundings to the gas

7) Which of the following is always true for an isothermal process of an ideal gas?

- A) The internal energy does not change
- B) No heat flows into or out of the system
- C) The pressure does not change
- D) The volume does not change
- E) No work is done by or on the system

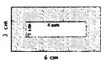
8) The average speed of the atoms of a gas at 100 K is 200 m/s. What would most nearly be the average speed of the atoms at 300 K?

- A) 67 m/s
- B) 140 m/s
- C) 200 m/s
- D) 350 m/s
- E) 600 m/s

9) Which of the following temperatures would be most appropriate to keep milk at inside a refrigerator?

- A)  $-20^\circ\text{C}$
- B)  $5^\circ\text{K}$  ( $= -268^\circ\text{C}$ )
- C)  $40^\circ\text{C}$
- D)  $273^\circ\text{K}$  ( $= 5^\circ\text{C}$ )
- E)  $350^\circ\text{K}$  ( $= 77^\circ\text{C}$ )

10) A rectangular piece of metal 3cm high by 6cm wide has a hole cut in its center 1cm high by 4cm wide as shown in the diagram at right. As the metal is warmed from  $0^\circ\text{C}$  to  $100^\circ\text{C}$  what will happen to the dimensions of the hole?



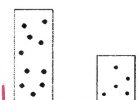
- A) both height and width will increase
- B) both height and width will decrease
- C) both height and width will remain unchanged
- D) height will decrease while width will increase
- E) height will increase while width will decrease

11) A gas is enclosed in a cylindrical piston. When the gas is heated from  $0^\circ\text{C}$  to  $100^\circ\text{C}$ , the piston is allowed to move to maintain a constant pressure. According to the Kinetic-Molecular Theory of Matter

- A) the mass of the gas will increase
- B) the number of molecules of gas must increase
- C) the size of the individual molecules has increase
- D) the average speed of the molecules has increased
- E) the molecules continue to strike the sides of the container with the same energy.

12) Two containers are filled with gases at the same temperature. In the container on the left is a gas of molar mass  $2M$ , volume  $2V$ , and number of moles  $2n$ . In the container on the right is a gas of molar mass  $M$ , volume  $V$ , and moles  $n$ . Which is most nearly the ratio of the pressure of the gas on the left to the pressure of the gas on the right?

- A) 1:1
- B) 2:1
- C) 4:1
- D) 8:1
- E) 16:1



13) A thermally insulating container has a membrane separating the container into two equal parts. In one part is a vacuum. In the other part is an ideal gas of temperature  $T$  and internal energy  $U$ . The membrane is punctured and the gas rushes into the region which was a vacuum. After the system has returned to equilibrium, which of the following is NOT true for the gas?

- A) The temperature of the gas is unchanged (True)
- B) No work is done by the gas on the surroundings (True)
- C) There is no heat exchanged by the gas with the surroundings (True)
- D) There is no entropy change (False)
- E) The internal energy of the gas is unchanged (True)

14) According to the kinetic theory of gases, when the absolute temperature of an ideal gas doubles, the average kinetic energy of the molecules of the gas

- A) quadruples
- B) doubles
- C) stays the same
- D) is cut in half
- E) is quartered

$K = \frac{3}{2} k_B T$   
 $= (1)(1)(2)$   
 $= 2$

15) When gas escapes from a pressurized cylinder, the stream of gas feels cool. This is because ...

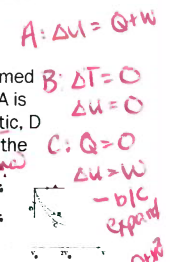
- A) work is being done at the expense of thermal energy
- B) of the convection inside the cylinder
- C) pressurized cylinders are good insulators
- D) the gas inside the cylinder is frozen
- E) moisture in the air condenses & cools

16) If two molecules in a gas collide, then

- A) total momentum is always exchanged
- B) velocities are always exchanged
- C) both molecules always speed up
- D) total kinetic energy always increases
- E) velocities are always unchanged

17) The PV diagram shows four different possible reversible processes performed on a monatomic ideal gas. Process A is isobaric, B is isothermal, C is adiabatic, D is isochoric. For which process does the temperature decrease?

- A) A
- B) C
- C) C and D
- D) B, C, D
- E) All four



18) A new monatomic ideal gas is discovered. A pure 4 mole sample is sitting in a container at equilibrium in a  $20^\circ\text{C}$  environment. According to the kinetic theory of gases, what is the average kinetic energy per molecule for this gas

- A)  $4.14 \times 10^{-22} \text{ J}$
- B)  $6.07 \times 10^{-21} \text{ J}$
- C)  $2.02 \times 10^{-21} \text{ J}$
- D)  $3652 \text{ J}$
- E) Molar mass of the gas is needed

$K = \frac{3}{2} k_B T$   
 $= \frac{3}{2} (1.38 \times 10^{-23} \text{ J/K}) (293 \text{ K})$   
 $= 6.065 \times 10^{-21} \text{ J}$

19) A metal rod of length  $L$  and cross-sectional area  $A$  connects two thermal reservoirs of temperature  $T_1$  and  $T_2$ . The amount of heat transferred through the rod per unit time is directly proportional to

- A)  $\sqrt{A}$  and  $L^2$
- B)  $\frac{1}{A}$  and  $\frac{1}{L}$
- C)  $A$  and  $L$
- D)  $A$  and  $\frac{1}{L}$
- E)  $\frac{1}{A}$  and  $L$

$Q = \frac{k A \Delta T t}{L}$

$Q \sim A$   
 $Q \sim \frac{1}{L}$

$P = \frac{nRT}{V}$   
 $n = \frac{m}{M}$   
 $\Rightarrow P = \frac{mRT}{MV}$   
 molecular mass  
 $A \rightarrow C \Delta U = Q + W = 30 - 20 = 10 \text{ J}$   
 $A \rightarrow B \rightarrow C \Delta U = Q + W = 25 - 15 = 10 \text{ J}$   
 $A \rightarrow B \rightarrow C \Delta U = Q + W = 25 - 10 = 15 \text{ J}$

$\Delta U = 0$   
 $Q$  must be -  
 \*They use thermal for heat  
 $T \uparrow$

$\Delta T = 0$   
 $\Delta U = 0$

$K = \frac{1}{2} mv^2 = \frac{3}{2} k_B T$   
 $v = \sqrt{\frac{3k_B T}{m}}$   
 $= \sqrt{\frac{(1)(1)(3)}{(1)}}$   
 $= \sqrt{3}$

$\sqrt{3} (200 \text{ m/s})$   
 $0^\circ\text{C} = \text{freezing}$   
 $100^\circ\text{C} = \text{boil}$

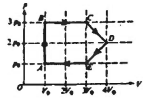
$\Delta Q = 0$   
 $\Delta U = W = -P \Delta V$   
 $\Delta U = W = -P \Delta V$   
 $\Delta U = W = -P \Delta V$   
 True  
 True  
 True  
 True

everything gets bigger

20) An ideal gas confined in a box initially has pressure  $P$ . If the absolute temperature of the gas is doubled and the volume of the box is quadrupled, the pressure is

- A)  $P/8$                       D)  $2P$   
 B)  $P/2$                       E)  $P/4$   
 C)  $P$

Questions 21 and 22 refer to the following:



An ideal gas undergoes a cyclic process as shown on the graph above of pressure  $P$  versus volume  $V$ .

21) At which point is the gas at its highest temperature?

- A) A                              D) D  
 B) B                              E) E  
 C) C

$D: \frac{2 \cdot 4}{1 \cdot 1} = 8$   
 $E: \frac{1 \cdot 3}{1 \cdot 1} = 3$

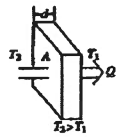
22) During which process is no work done on or by the gas?

- A) EA                              D) DE  
 B) CD                              E) BC  
 C) AB *no  $\Delta V$*

23) Which of the following is always characteristic of an adiabatic process?

- A) No heat flows into or out of the system ( $Q = 0$ )  
 B) The internal energy does not change ( $\Delta U = 0$ )  
 C) No work is done on or by the system ( $W = 0$ )  
 D) The pressure does not change ( $\Delta P = 0$ )  
 E) The temperature does not change ( $\Delta T = 0$ )

24) In time  $t$ , an amount of heat  $Q$  flows through the solid door of area  $A$  and thickness  $d$  represented below.



$$Q = \frac{kA\Delta T t}{d}$$

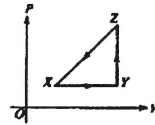
$$= \frac{kA(T_2 - T_1)t}{d}$$

The temperature on each side of the door are  $T_2$  and  $T_1$  respectively. Which of the following changes would be certain to decrease  $Q$ ?

- A) Increasing  $d$ ,  $A$ , and  $T_2 - T_1$   
 B) Increasing  $d$  and  $T_2 - T_1$  only  
 C) Decreasing  $A$  and  $T_2 - T_1$  only  
 D) Increasing  $A$  only  
 E) Decreasing  $d$  only

$\downarrow Q: \downarrow k \downarrow A \downarrow (T_2 - T_1) \downarrow t$   
 $\uparrow d$

Questions 25 and 26 refer to the following:



A thermodynamic system is taken from an initial state  $X$  along the path  $XYZX$  as shown in the  $PV$  diagram above.

25) For the process  $Y \rightarrow Z$ ,  $Q$  is greater than zero and

- A)  $W < 0$  and  $\Delta U = 0$   
 B)  $W > 0$  and  $\Delta U = 0$   
 C)  $W > 0$  and  $\Delta U > 0$   
 D)  $W = 0$  and  $\Delta U < 0$   
 E)  $W = 0$  and  $\Delta U > 0$

$YZ$  ①  $\Delta V = 0$   
 $W = -P\Delta V$   
 ②  $\Delta U = Q + W$   
 $\Delta U = Q$   
 since  $Q +, \Delta U +$

26) For the process  $X \rightarrow Y$ ,  $\Delta U$  is greater than zero and

- A)  $Q > 0$  and  $W < 0$   
 B)  $Q < 0$  and  $W = 0$   
 C)  $Q > 0$  and  $W = 0$   
 D)  $Q > 0$  and  $W > 0$   
 E)  $Q < 0$  and  $W > 0$

$XY$  ③  $V \uparrow$  expand,  $W -$   
 ②  $\Delta u = Q + W$   
 $(+) = (-) + (-)$

$Q$  must be  $+$

- 1/E  
 2/E  
 3/E  
 4/D  
 5/D  
 6/A  
 7/A  
 8/D  
 9/D  
 10/A  
 11/D  
 12/A  
 13/D  
 14/B  
 15/A  
 16/A  
 17/C  
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 21/C  
 22/A  
 23/A  
 24/C  
 25/E  
 26/A