Questions 1-2. Consider an ideal gas at temperatures $T_1$ and $T_2$. The Maxwell distributions of speeds at these two temperatures are shown in the picture below.

![Maxwell distribution of speeds](image)

1. Based on these speed distributions we know that:
   
   (a) $T_1 > T_2$  
   (b) $T_1 = T_2$  
   (c) $T_1 < T_2$  
   (d) $T_1 = 2T_2$

2. At temperature $T_1$ the speed $v_1$ is:
   
   (a) mean speed  
   (b) rms speed  
   (c) most probable speed  
   (d) neither

Questions 3-4. Consider 3 mol of ideal gas at $T= 200$ K.

3. What is the average kinetic energy $\overline{K}$ of its molecules? ($k$ is Boltzmann’s constant)
   
   (a) $200k$  
   (b) $300k$  
   (c) $400k$  
   (d) $500k$

4. What is the internal energy $U$ of the gas? (R is the universal gas constant)
   
   (a) $400R$  
   (b) $600R$  
   (c) $900R$  
   (d) $1000R$
Questions 5-6. Consider four particles with speeds: 1 m/s, 4 m/s, 2 m/s and 1 m/s.

5. The mean speed \( \bar{v} \) is:
   (a) 1 m/s  (b) 2 m/s  (c) 3 m/s  (d) 4 m/s

6. The root-mean-square speed \( v_{rms} \) is:
   (a) \( \sqrt{3.8} \) m/s  (b) \( \sqrt{4.7} \) m/s  (c) \( \sqrt{5.5} \) m/s  (d) \( \sqrt{6.1} \) m/s

Questions 7-8. Consider \( n= 2 \) mol of an ideal gas at temperature \( T \), pressure \( P \) and volume \( V \).

7. If pressure doubles, but the volume stays the same, what is the new temperature?
   (a) \( \frac{T}{2} \)  (b) \( T \)  (c) \( 2T \)  (d) \( 4T \)

8. If pressure doubles, but the temperature stays the same, what is the new volume?
   (a) \( \frac{V}{2} \)  (b) \( V \)  (c) \( 2V \)  (d) \( 4V \)

9. In isochoric processes:
   (a) \( T= \) const  (b) \( P= \) const  (c) \( V= \) const  (d) \( Q= 0 \)

10. Consider a 100 m long aluminum beam. How much will it expand when the temperature raises from 20 \(^\circ\)C to 60 \(^\circ\)C? The coefficient of thermal expansion of aluminum is \( \alpha=25 \times 10^{-6} \) \(^\circ\)C\(^{-1} \).
    (a) 0.1 cm  (b) 1 cm  (c) 10 cm  (d) 100 cm

11. Heat is energy that is transferred from one body to another because of a difference in temperature.
    (a) True  (b) False  (c) cannot be answered

12. The first law of thermodynamics can be expressed as:
    (a) \( \Delta Q = U - T \)  (b) \( \Delta W = U + V \)  (c) \( \Delta Q = R - U \)  (d) \( \Delta U = Q - W \)
Questions 13-16. 1 m$^3$ of ideal gas initially at 100 kPa of absolute pressure (state A) is allowed to expand isothermally until the pressure is 10 kPa (state B). It is then compressed at constant pressure to its initial volume (state C) and lastly is brought back to its original pressure (state A) by heating at constant volume.

13. Which PV diagram describes this process?

![Diagram options](image)

14. What is the volume $V_2$?

(a) 0.1 m$^3$  
(b) 1 m$^3$  
(c) 10 m$^3$  
(d) 100 m$^3$

15. How much work is done on the gas between states B and C?

(a) 0  
(b) 50 kJ  
(c) 90 kJ  
(d) 100 kJ

16. How much work is done between states C and A?

(a) 0  
(b) 50 kJ  
(c) 90 kJ  
(d) 100 kJ
17. The boiling temperature of water is:

(a) 32 °F    (b) 212 K    (c) 100 °C    (d) 273 K

18. Heat of vaporization $L_V$ is the heat required to change 1 kg of substance from liquid to solid phase.

(a) True    (b) False    (c) cannot be answered

**Questions 19-20.** 1 kg of water at 80 °C is poured into a 1 kg glass cup initially at 20 °C. The specific heat of glass is $c_{\text{glass}} = \frac{840}{\text{J kg} \cdot ^\circ \text{C}}$. Assume $c_{\text{water}} = 9c_{\text{glass}}$.

19. What will be the equilibrium temperature?

(a) 32 °C    (b) 45 °C    (c) 68 °C    (d) 74 °C

20. How much heat will the cup receive in the process?

(a) 45,360 J    (b) 57,290 J    (c) 63,120 J    (d) 77,410 J