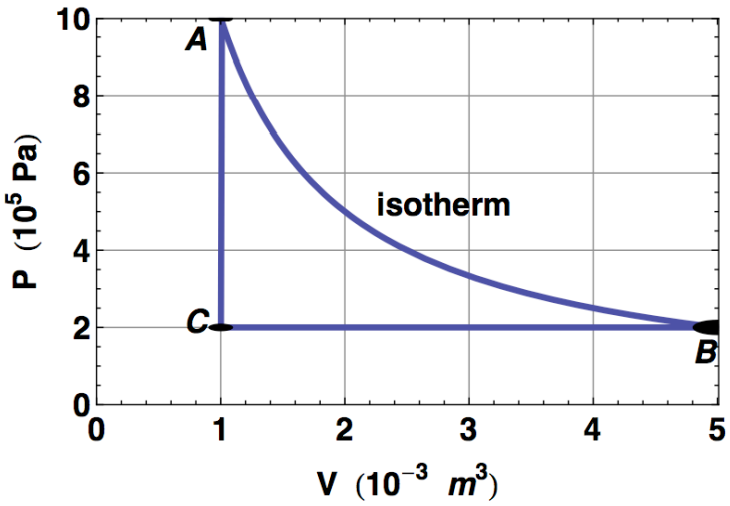
Questions are worth 6 points, except as shown



For questions 1-5: The P-V diagram above is for an ideal monatomic gas.
For this system n=0.24, so nR = 2.0 J/K.
The area under the Isothermal path between points A and B is approx. 1600 J (or N-m).
Temperatures are at the points marked: T_A, T_B, T_C

1. What is the temperature, T_A (in K) at point A?

A) 200
B) 100
C) 400
D) 500
E) 1000

Ans: D. T=PV/nR=(106 kPa)(10^{-3} m^3)/(2 J/K)=500K

2. What is the temperature, T_B at point B?

A) T_A
B) T_A /2
C) T_A /10
D) T_A /5
E) T_A /2.5

Ans: A. Isothermal connects A and B

3. During the process A to B, is work (W_{AB}) done by the gas or on the gas?

A) By

B) On

C) No work is done

Ans: A. Gas is expanding, work is done BY gas

4. During the process A to B, does heat (Q_{AB}) flow into the gas or out of the gas?

A. Into

B. Out of

C. No heat flow

Ans: A. Work is done BY gas, so must add heat to keep U (~T) constant.

5. During the process B to C, is work (W_{BC}) done by the gas or on the gas?

A. By

B. On

C. No work done

Ans: B. Compression at constant P, so work done ON gas = area under B-C curve

6. What is the efficiency of a heat engine that exhausts 1200 J of heat in the process of doing 250 J of work ?

A. 75 %

B. 33 %

C. 47 %

D. 66 %

E. 17 %

Ans: E. $Q_H = Q_C + W = 1200J + 250J$; $\varepsilon = 1 - (Q_C / Q_H) = 1 - (1200J/1450J) = 0.17$

7. With the pressure held constant at 170 kPa, 50 mol of an ideal monatomic gas expands from an initial volume of 1.5 m^3 to a final volume of 2.9 m^3 .

How much work was done by the gas during the expansion?

A. 189 kJ

B. 200

C. 67

D. 238

E. 100

Ans: D. $W = P\Delta V = 170kPa\ (2.9 - 1.5\ m^3) = 238\ kJ$

8. An air conditioner which is an ideal Carnot engine operates between an indoor temperature of 20°C and an outdoor temperature of 39°C. How much energy (work) must it provide to remove 2000 J of heat from the inside of the house?

A) 105 J

B) 130 J

C) 780 J

D) 520 J

E) 340 J

Ans: B. Carnot efficiency =(1- *T*c/ *T*h) =(1- *Q*c/ *Q*h)→ *Q*h= *Q*c(*T*h/ *T*c) =2000(312/293)=2129.7J so require W= *Q*h – *Q*c =129.7 J

9. Find the change in Entropy when 1 kg of water is boiled away to steam . (both water and steam are at 100 ^{o}C)

A. 9.71 kJ/Kelvin
B. 6.06
C. 1.94
D. 5.62
E. 4.56

Ans: B. $\Delta Q = mL = 1kg\ (2.26x10^6\ J/kg)$; $\Delta S = \Delta Q/T = 2.26x10^6\ J / 373K = 6.06kJ/K$

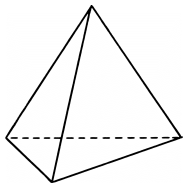
10. What is the magnitude of the electric field produced at a distance of 520 m by a charge of 7 Coulombs ?

A. 0.38 Megavolts/meter
B. 1.73
C. 0.23
D. 1.94
E. 6.37

Ans: C. $E = k Q/ R^2 = (8.99 \times 10^9\ N.m^2/C^2)(7C)/(520\ m)^2 = 0.233\ MV/m$

11. A box in the form of a Tetrahedron contains electric charge. The electric fluxes through the four sides of the box are as follows :

Flux1 = – 113 N. m^2/C ;
Flux2 = + 144 N. m^2/C;
Flux3 = + 26 N. m^2/C;
Flux4 = –12 N. m^2/C



Find the electric charge inside this box.

A. 0.398 nano Coulombs
B. 0.144
C. 0.74
D. 0.796
E. – 0.74

Ans: A. $\Sigma\Phi = 45\ N.m^2/C = Q/\varepsilon_0$; $Q = 45\ N.m^2/C\ (8.85 \times 10^{-12}\ C^2/N.m^2) = 0.398x10^{-9}\ C$

For questions 12-13: An isolated parallel-plate capacitor has plates with an area of 0.017 m^2 and separation of 0.87 mm. Initially, the space between the plates is filled with a dielectric whose dielectric constant is 2.0.

12. What is the potential difference between the plates when the charge on the capacitor plates is $\pm$ 4.7 μC?

A) 13.6 kV

B) 27.2 kV

C) 54.4 kV

D) none of the above

Ans: A

$$C = \kappa\left(\varepsilon_0 A / d\right)$$

$$= 2\left(8.85\times10^{-12}\,\text{F/m}\right)\left(0.017\ \text{m}^2\ \right)/0.00087\text{m}$$

$$= 344\ \text{pF}$$

$$V = Q/C = \left(4.7\times10^{-6}\text{C}\right)/\left(344\times10^{-12}F\right) = 13.6kV$$

13. (4 pts.) Would your previous answer increase, decrease, or stay the same, if we remove the dielectric material, leaving the gap empty space (so, the dielectric constant is reduced to 1.0), all else staying the same?

A) stay the same

B) increase

C) decrease

Ans: B. increase, because V is inversely proportional to κ: V =Q/C=Q/(κC0).

14. Find the electric energy density between the plates of a 1.0 F parallel plate capacitor. The potential difference between the plates is 100 V and the plate separation is 1 mm . There is a vacuum between the plates.

A. 0.067 J/m^3
B. 0.172
C. 0.057
D. 0.044
E. 0.095

Ans: D. -E=ΔV/Δs =(100V/0.001m)=100kV/m; $u=\frac{1}{2}\varepsilon_0 E^2=\frac{1}{2}(8.85\times10^{-12})(10^5)^2$ J/m^3

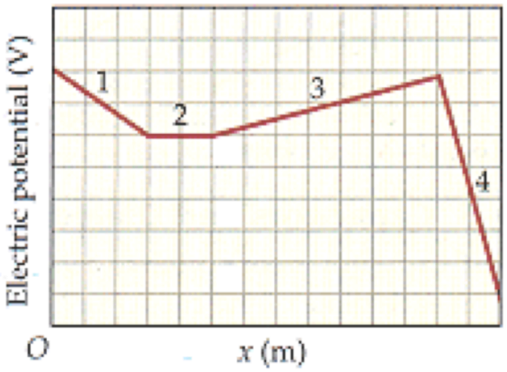
15. An electron accelerates through a potential difference of 3000 V from rest . Find its final velocity .

A. 0.42 (x 10^8 m/s)
B. 0.32
C. 1.3
D. 0.76
E. 0.15

Ans: B. KE=ΔU; $\frac{1}{2}mv^2 = q\Delta V$; $v^2=2q\Delta V/m$

$v^2=2(1.6\times10^{-19}\,C)3000V/(9.11\times10^{-31}kg)=1054\times10^{12}$; $v=32\times10^6$ m/s

For questions 16 -18: As a positive test charge moves along the x axis from $x = 0$ to $x = 1.4$ m, the electric potential it experiences is shown in the figure, below. (The horizontal axis is marked in increments of 0.1 m and the vertical axis is marked in increments of 0.5 V.)



16. (4 pts.) For which part of its path is the electrostatic force on the charge zero?

A. segment 1
B. segment 2
C. segment 3
D. segment 4
E. none of the above

Ans: B (E=0=slope of plot; slope=0 for segment 2)

17. (4 pts.) For which part of its path does the electrostatic force point in the –x direction?

A. segment 1
B. segment 2
C. segment 3
D. segment 4
E. none of the above

Ans: C (E = negative; slope of 3 =negative)

18. (4 pts.) For which part of its path is the electrostatic force largest in magnitude?

A. segment 1
B. segment 2
C. segment 3
D. segment 4
E. none of the above

Ans: D (slope=steepest)