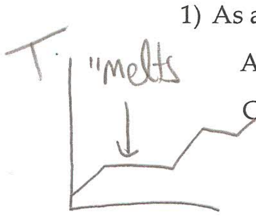
Name KEY

Exam 1 19 questions

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



1) As a solid substance melts, ______________________.

A) the temperature of the substance ~~decreases~~. B) energy is transferred ~~from~~ the substance.

C) the temperature of the substance ~~increases~~. D) energy is transferred to the substance. ✓

2) A cylindrical bar that us well insulated around its sides connects hot and cold reservoirs and conducts heat at a rate of 10.0 J/s under steady state conditions. If all of its linear dimensions (diameter and length) are reduced by half, the rate at which it will now conduct heat between the same reservoirs is closest to ______________.

A) 1.25 J/s. πr_1^2 B) 2.50 J/s. C) 80.0 J/s. D) 20.0 J/s. E) 5.00 J/s. ✓

$H_1 = 10 = \frac{kA_1\Delta T}{L_1}$ || $H_2 = \frac{kA_2\Delta T}{L_2}$ if $A_2 = \pi\left(\frac{r}{2}\right)^2$ and $L_2 = \left(\frac{L_1}{2}\right)$ Then $H_2 = \frac{1}{2} kA_1\Delta T / L_1$ ☺

3) A 648-g empty iron kettle is put on a stove. How much heat. in joules. must it absorb to raise its temperature from 15.0°C to 37.0°C? (The specific heat for iron is 473.47 J/kg•C°)

A) 1610 J Still solid B) 16,100 J C) 6750 J ✓ D) 11,300 J

$Q = MC\Delta T = 0.648 * 473.47 * (22) = \underline{6750\ J}$

4) A heat engine with an efficiency of 30.0% performs 2500 J of work. How much heat is discharged to the lower temperature reservoir?

A) 1350 J B) 5830 J ✓ C) 8330 J D) 7080 J E) 750 J

$e = \frac{W}{Q_H} = 0.3$ $\therefore Q_H = \frac{W}{0.3} = 8333\ J$ || 1^{st}: $Q_H = W + Q_C$ $\therefore Q_C = Q_H - W = \underline{5833\ J}$

5) A Carnot engine operates between a high temperature reservoir at 435 K and a river with water at 280 K. If it $\boxed{\text{absorbs 3700 J}}$ of heat each cycle, how much work per cycle does it perform?

Q_H

✓ A) 1318 J B) 2382 J C) 1449 J D) 2251 J

$e = \frac{get}{pay} = \frac{W}{Q_H} \Rightarrow \frac{Q_H - Q_C}{Q_H} = 1 - \frac{Q_C}{Q_H}$

1^{st}: $Q_H = W + Q_C$ $\therefore W = Q_H - Q_C$

So $e_{Carnot} = 1 - \frac{T_C}{T_H} = 0.356$

$\therefore 0.356 = \frac{W}{Q_H}$

$\Rightarrow W = 0.356 Q_H = \underline{1317\ J}$

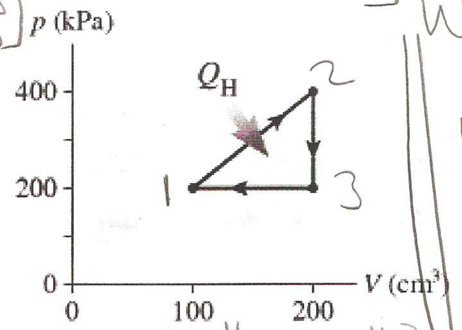
6) The graph in the figure shows a cycle for a heat engine for which Q_H=35 J (that is the net heat transfer for the cycle). What is the thermal efficiency of this engine? NOTE: In reading this diagram, recall that SI units are pascals and meters.

$W_{net} = \frac{1}{2}(1\times10^{-4})(200\times10^{3})$

$= +10$ Joules

BY SYSTEM

$e = \frac{get}{pay} = \frac{W}{Q_H} = \frac{10}{35}$



$1\times10^{-4} m^3$ $2\times10^{-4} m^3$

$W_{1\to2}$ = + area under path

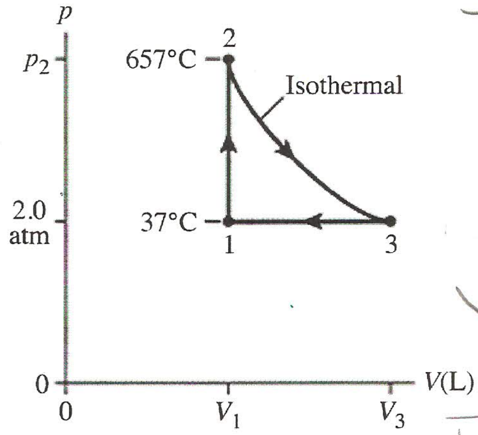
$W_{2\to3} = 0$

$W_{3\to1}$ = − area under path.

∴ W_{net} = + Area enclosed

A) 29 % B) 23 % C) 14 % D) 57 %

7) The figure (not to scale) shows a pV diagram for 0.45 moles of helium gas (He) that is cycled between three states. State 3 is at the same temperature as state 2. For the process that takes the gas from state 2 to state 3, ________________________.



$T_2 = T_3$ Given

System does work

∴ Must have heat to system

A) the system does work and heat transfer is to the system
B) the system does work and there is no heat
C) the system does work and heat transfer is from the system
D) there is no work or heat.

8) A solid concrete wall 4.0 m wide by 2 .4 m tall and 30 cm thick, with a thermal conductivity of 1.3 W/(m•K), separates a basement at 18°C from the ground outside at 6°C. Under steady state conditions, how much heat flows through the wall in one hour?

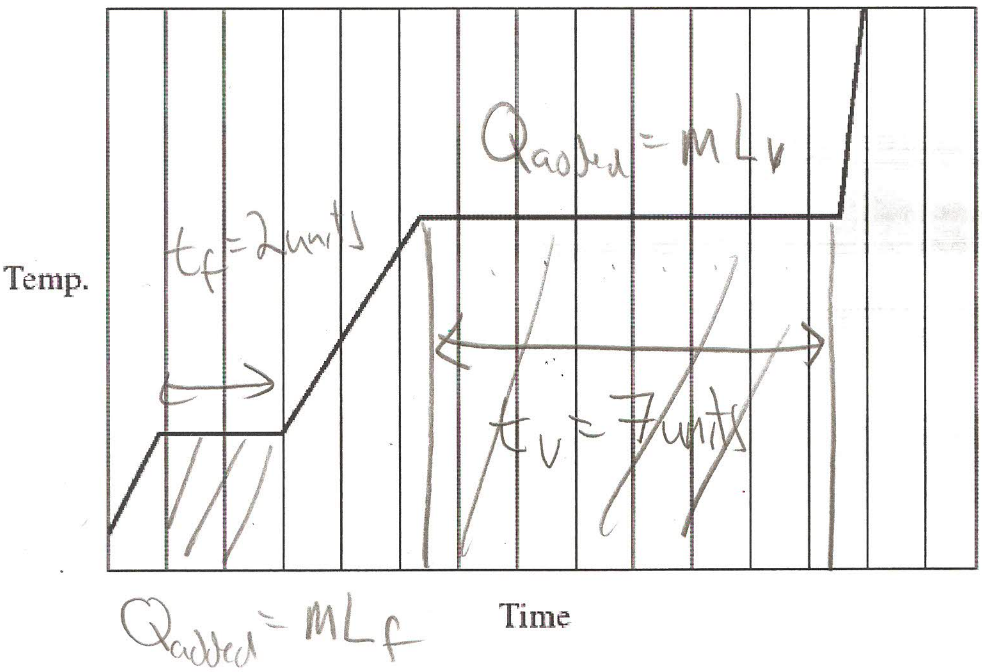
A) 5.0 kJ B) 1.8 MJ C) 5.0 MJ D) 1.8 kJ E) 500 J

$H = \frac{KA\Delta T}{L} = \frac{1.3(4\times2.4)(12)}{0.3} = 499.2\ J/s$

$499.2\ J/s \times \frac{3600\ s}{hr} = 1.8\times10^{6}\ J$

$\therefore$ $Q_{added} \propto$ Time $\therefore \frac{Q_V}{Q_f} = \frac{t_v}{t_f}$

9) Heat is added to a pure substance in a closed container at a constant rate. The figure shows a graph of the temperature of the substance as a function of time. If L_f = latent heat of fusion and L_V = latent heat of vaporization, what is the value of the ratio L_V / L_f for this substance?



$\frac{Q_V}{Q_f} = \frac{mL_v}{mL_f}$

$\frac{t_v}{t_f} = \frac{L_v}{L_f}$

$\frac{7}{2} = \frac{L_v}{L_f}$

A) 5.0 B) 4.5 C) 1.5 D) 3.5 ✓ E) 7.2

A 'thinking' question

Another 'thinking' question

10) It is a well-known fact that water has a higher specific heat than iron. Now, consider equal masses of water and iron that are initially in thermal equilibrium. The same amount of heat, 30 calories, is added to each one. Which statement is true?

A) It is impossible to say without knowing the exact mass involved.
B) It is impossible to say without knowing the exact specific heats.
C) They are no longer in thermal equilibrium; the iron is warmer.
D) They remain in thermal equilibrium.
E) They are no longer in thermal equilibrium; the water is warmer.

$Q_{Fe} = M_{Fe} C_{Fe} \Delta T_{Fe}$

$Q_{H_2O} = M_{H_2O} C_{H_2O} \Delta T_{H_2O}$

Given: $M_{Fe} = M_{H_2O}$
$Q_{Fe} = Q_{H_2O}$
$C_{H_2O} > C_{Fe}$

$\Delta T_{Fe} = \frac{Q}{mC_{Fe}}$ $\Leftarrow$ Larger!

$\Delta T_{H_2O} = Q / mC_{H_2O}$

11) An air conditioner with a coefficient of performance of 3.5 uses 30 kW of power. How much power is it discharging to the outdoors?

A) 105 kW B) 210 kW C) 30 kW D) 75 kW E) 135 kW

Consider 1 sec.

$W = 30 \times 10^3$ J

$COP = 3.5 = \frac{Q_c}{W}$

$\therefore Q_c = 3.5W = 1.05 \times 10^5$ J

1^{st}: $Q_c + W = Q_H$

$\therefore Q_H = 30 \times 10^3 + 1.05 \times 10^5$

$= 135 \times 10^3$ J

$C.O.P. = \frac{Q_c}{W} = 4.2 \therefore W = \frac{Q_c}{4.2} = 59.5\,J$

12) A $\boxed{\text{refrigerator}}$ has a coefficient of performance equal to 4.2. How much work must be done on the refrigerator in order to remove 250 J of heat from the interior?

A) 480 J B) 250 J C) 60 J D) 120 J E) 1050 J

13) If 2.0 g of water at 0.00°C is to be vaporized, how much heat must be added to it? The specific heat of water is 1.0 cal/g•K, its heat of fusion is 80 cal/g, and its heat of vaporization is 539 cal/g.

A) 1300 cal B) 1200 cal C) 1100 cal D) 1500 cal E) 1100 kcal

Stick w/the units given ☺ || $Q_{TOTAL} = mc\Delta T + mL_v = 2(1)(100) + 2(539) = 1278$ cal

14) A certain $\boxed{\text{engine}}$ extracts 1300 J of heat from a hot temperature reservoir and discharges 700 J of heat to a cold temperature reservoir. What is the efficiency of this engine?

A) 27% B) 86% C) 54% D) 13% E) 46%

1^{st}: $Q_H = W + Q_C$

$\therefore W = Q_H - Q_C = 600$ || $e = \frac{W}{Q_H} = \frac{600}{1300} = 0.46$

15) Under steady state conditions, a piece of wood 350 mm by 350 mm and 15 mm thick conducts heat through its thickness and loses no appreciable heat through its well-insulated sides. The rate of heat flow is measured to be 14.0 W when the temperature difference across its thickness is 28 C°. Determine the thermal conductivity of this wood.

A) 9.2×10^{-4} W/(m•C°)

B) 270 W/(m•C°)

C) 16 W/(m•C°)

D) 0.061 W/(m•C°)

E) 33 W/(m•C°)

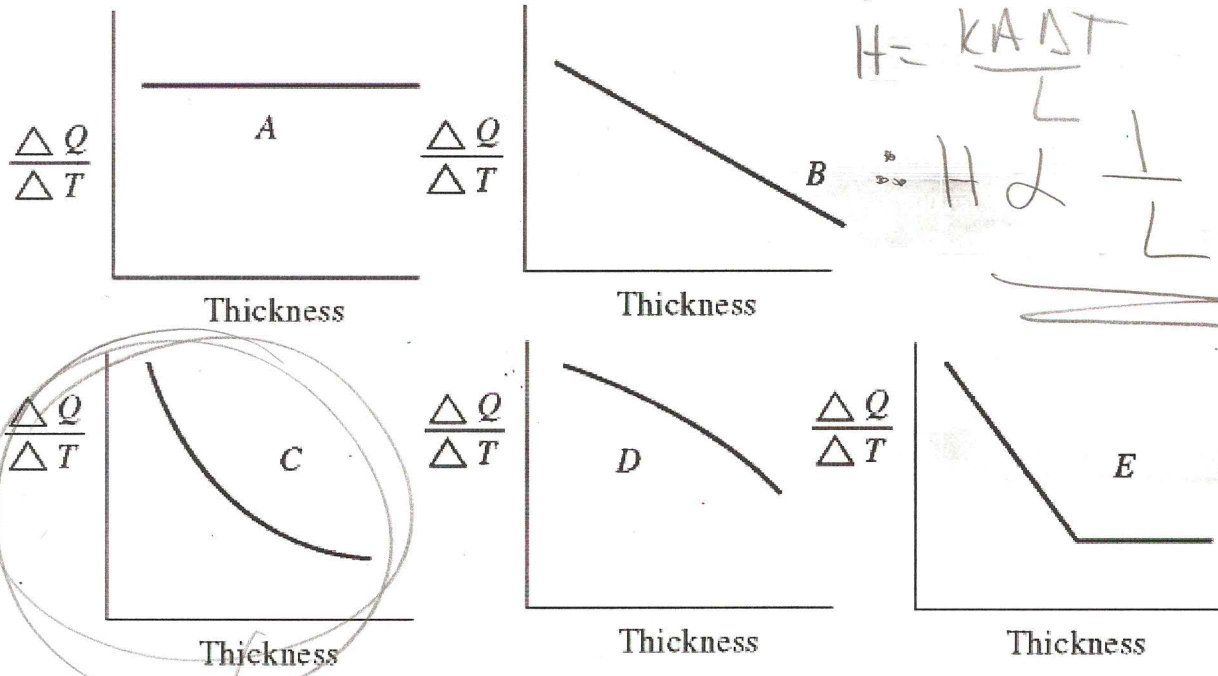
$$H = \frac{kA\Delta T}{L}$$

$$\therefore k = \frac{HL}{A\Delta T} = \frac{14 \times (15 \times 10^{-3})}{(350 \times 10^{-3})^2 (28)}$$

$$= 0.061$$

OVER →

16) An architect is interested in estimating the heat loss (in kcal/s) through a sheet of insulating material as a function of the thickness of the sheet. Assuming fixed temperatures on the two faces of the sheet, which one of the graphs in the figure best represents the rate of heat transfer as a function of the thickness of the insulating sheet? NOTE: The "T" shown in the axis labels below stands for 'time', not temperature.



$H = \frac{KA\Delta T}{L}$

$\therefore H \propto \frac{1}{L}$

Another "thinking" question

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

only graph w/ correct shape.

17) The compressor in a certain Carnot refrigerator performs 480 J of work to remove 150 J of heat from the interior of the refrigerator. How much heat must the coils behind the refrigerator discharge into the kitchen?

A) 630 J B) 480 J C) 110 J D) 150 J E) 330 J

1^{st}: $Q_C + W = Q_H$ $\therefore Q_H = 480 + 150 = 630\,J$

18) A nuclear fission power plant has an actual efficiency of 39%. If 0.25 MW of power are produced by the nuclear fission, how much electric power does the power plant output?

This is the fuel

A) 0.098 MW B) 9.8 MW C) 35 MW D) 0.35 MW

Consider 1 second: $e = 0.39 = \frac{W}{Q_H}$ $\therefore W = 0.39\,Q_H = 0.39 * 0.25 = 0.098$

19) 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 J/kg•K.

A) 5.3 s B) 22 s C) 93 s D) 114 h

$Q_{needed} = mc\Delta T = 0.148 * 4190 * 10 = 6201.2\,J$

$\frac{6201.2\,J}{67\,J/s} = 92.6$ seconds