	Total	K+E	I+O
Student	36	19	17
Average	39.7/100	35.2/100	44.7/100
Best	71.5/100	71.5/100	71.5/100

11^{th}G Physics (2018– 19)

2^{nd} Q Exam- Honors

(January 23, 2018)

Class	No.	Name Solutions

In calculation problems, describe equations clearly and systematically enough to show how to solve the problems. If not enough, you won't get any points.

5 points/problem x 21 problems= 105 points(Max 100 points)

Exam	／[Total 100 points]
Lab Reports	
Homework	

The circular constant $\pi = 3.14159...$

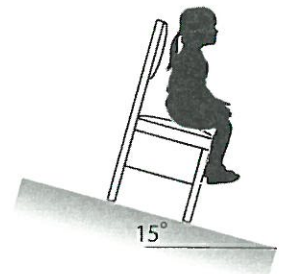
Gravitational acceleration rate $g = 9.80\ m/s^2$

	Density [kg/m^3]
Gold	19,300
Silver	13,600
Iron	7,860
Sea water	1,025
Water	1,000
Ice	917
Air	1.29
Helium	0.179
Hydrogen gas	0.0899

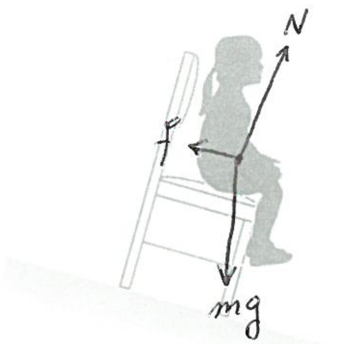
Specific Heat	c [J/(kg・K)]
Water	4186
Ice	2090
Steam	2010
Oil	1970
Copper	387
Ceramic	1090
Glass	837
Aluminum	900
Iron (Steel)	560
Lead	128

	Latent Heat of Fusion L_f [J/kg]	Latent Heat of Vaporization L_v [J/kg]
Water	3.35×10^5	22.6×10^5

(1, 2) A 9.5-kg child sits at rest in a 3.7-kg chair that is also at rest on a slope inclined at an angle of 15° with the horizontal, as shown in the figure.
(1) Draw a free-body diagram for the child, and find the normal force exerted on the child.
(2) Draw a free-body diagram for the chair, and find the normal force exerted by the slope on the chair.



(1) Answer Draw a free-body diagram for the child.



Normal Force: 90N

(Equations)

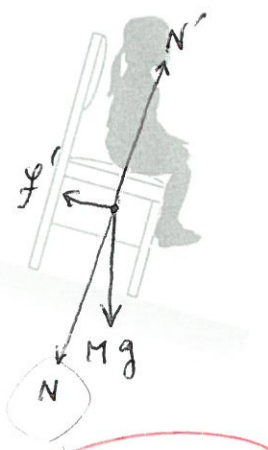
$N = mg\cos\theta$

$= 9.5 \times 9.80 \cos 15^\circ$

$= 89.9 \rightarrow 90$

(48%)

(2) Answer Draw a free-body diagram for the chair.



child on chair

Normal Force: 125 N

$N' = N + Mg\cos\theta$

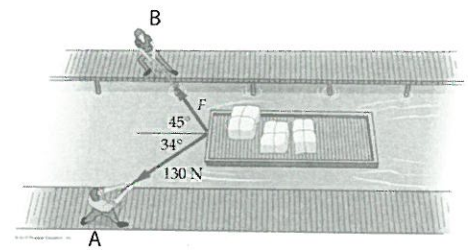
$= 89.9 + 3.7 \times 9.80 \cos 15^\circ$

$= 89.9 + 35.0$

$= 124.9 \rightarrow 125$

(37%)

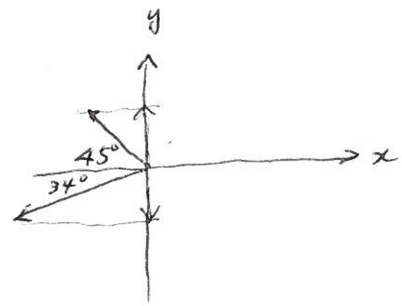
(3) Two crewmen, A and B, pull a raft through a canal, as shown in the figure. With what force should the crewman B pull so that the net force of the two crewmen is the forward direction? (Equations)



$$F_B \sin 45^\circ - 130 \sin 34^\circ = 0$$

$$F_B = \frac{130 \sin 34^\circ}{\sin 45^\circ}$$

$$= 102.8 \rightarrow 100\ (N)$$



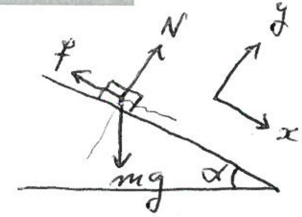
(3) Answer
100 N

(26%)

$(1.0 \times 10^2\ N)$

(4) A child goes down a playground slide with an acceleration of $1.26\ m/s^2$. The slide is inclined at an angle of 33.0° below the horizontal.
Find the coefficient of kinetic friction between the child and the slide.
(Equations)

$$\Sigma \vec{F} = m\vec{a}$$



$\alpha = 33.0°$

$\Sigma F_x = m a_x$

$mg\sin\alpha - f = m a_x$ — ①

$f = \mu N$ — ③

$\Sigma F_y = m a_y$

$N - mg\cos\alpha = m a_y = 0$

↓

$N = mg\cos\alpha$ — ②

① ~ ③

$$mg\sin\alpha - \mu mg\cos\alpha = m a_x$$

↓

$$g\sin\alpha - \mu g\cos\alpha = a$$

← ここが蒸発した人多い

$$\mu = \frac{g\sin\alpha - a}{g\cos\alpha} = \frac{9.80\sin 33° - 1.26}{9.80\cos 33°}$$

$$= \frac{5.337 - 1.26}{8.219} = \frac{4.077}{8.219}$$

$$= 0.4961$$

$$\rightarrow 0.496$$

(4) Answer
0.496

(23%)

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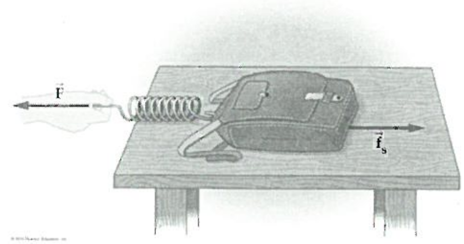
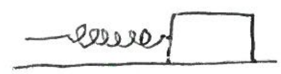
(5,6) A backpack full of books with the total mass is 5.23 kg rests on a table. A spring with a force constant of 150. N/m is attached to the backpack and pulled horizontally.
(5) If the spring is pulled until it stretches 2.00 cm and the pack remains at rest, what is the force of friction exerted on the backpack by the table?
(6) If the backpack begins to slide when the spring stretches by 2.50 cm, what is the coefficient of static friction between the backpack and the table?
(Equations)



(5) $F = kx$

$= 150 \times 0.0200$

$= 3.000 \rightarrow 3.00 (N)$



(6) $F = kx$

$= 150 \times 0.0250$

$= 3.750 (N)$

$F = \mu N = \mu m g$

$\mu = \frac{F}{mg}$

$= \frac{3.750}{5.23 \times 9.80}$

$= 0.07317$

$\rightarrow 0.0732$

(5) Answer
3.00 N

(51%)

(6) Answer
0.0732

(42%)

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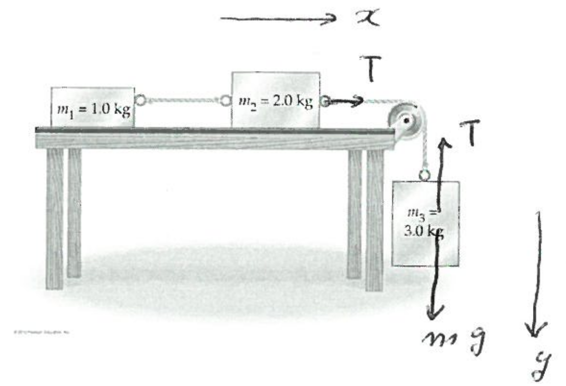
(7) Find the acceleration of the masses shown in the figure. Assume the table is frictionless and the masses move freely. (Equations)



m_1 and m_2

$(\Sigma F = ma)$

$T = (1.0 + 2.0)\,a$

$= 3.0\,a$ —— ①

m_3 $(\Sigma F = ma)$

$m_3 g - T = m_3 a$

$T = 3.0(9.80 - a)$

$= 29.40 - 3.0\,a$ —— ②

①, ② $3.0\,a = 29.40 - 3.0\,a$

$6.0\,a = 29.40$

$a = \dfrac{29.40}{6.0}$

$= 4.90 \longrightarrow 4.9\,(m/s^2)$

(7) Answer
$4.9\ m/s^2$

(17%)

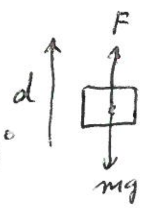
(8) You pick up 3.4 kg can of paint from the ground and lift if to a height of 1.8 m.
(8-a) How much work do you do on the can of paint?
(8-b) You hold the can stationary for half a minute, waiting for a friend on a ladder to take it. How much work do you do during the time?
(8-c)Your friend decides against the paint, so you lower it back to the ground. How much work do you do on the can as you lower it?
(Equations)

(a)

$W = Fd\cos\theta$

$= 3.4 \times 9.80 \times 1.8 \cos 0^\circ$

$= 59.98 \rightarrow 60$ (J)



(b) $W = Fd\cos\theta$

$= 0 \quad (\because d = 0)$

(c) $W = Fd\cos\theta$

$= 3.4 \times 9.80 \times 1.8 \cos 180^\circ$

$= -59.98$

$\rightarrow -60$ (J)

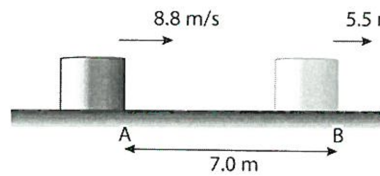
(8-a) Answer	60 J
(8-b) Answer	0
(8-c) Answer	−60 J

(59%)

2 answers correct → +3

7

(9) A 1.0 kg body is moving on a horizontal rough plane. The body passes at point A with a speed of 8.8 m/s and then at point B with a speed of 5.5 m/s. The distance between A and B is 7.0 m.
(9-a) Find the work done by the kinetic frictional force between A and B.
(9-b) Find the magnitude of the kinetic frictional force.
(9-c) Find the coefficient of kinetic friction.
(Equations)



(a) $W_{Total} = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$= \frac{1}{2} \times 1.0 \, (5.5^2 - 8.8^2) = -23.595 \rightarrow -24 \text{ (J)}$

(b) $W = F d \cos\theta$

$F = \frac{W}{d \cos\theta} = \frac{-23.595}{7.0 \times \cos 180^\circ} = \frac{-23.595}{-7.0} = 3.37 \rightarrow 3.4$

(c) $F = \mu N = \mu m g$

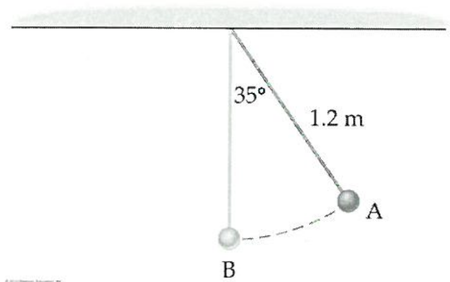
$\mu = \frac{F}{mg} = \frac{3.37}{1.0 \times 9.80} = 0.344 \rightarrow 0.34$

(9-a) Answer	-24 J
(9-b) Answer	3.4 N
(9-c) Answer	0.34

(51%)

(a) 24 J −1

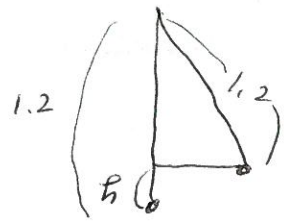
(10) A0.33-kg pendulum bob is attached to a string 1.2 m long. What is the change in the gravitational potential energy of the system as the bob swings from point A to point B? (Equations)



$h = 1.2 - 1.2\cos 35°$

$= 1.2 - 0.983$

$= 0.217$ (one digit)



$U_B = 0$

$U_A = mgh$

$= 0.33 \times 9.80 \times 0.217$

$= 0.702$

$\Delta U = U_B - U_A$

$= 0 - 0.702$

$= -0.702 \longrightarrow -0.7$ (J)

(10) Answer
-0.7 J

(35%)

0.7 J −1

−0.70 J −0.5

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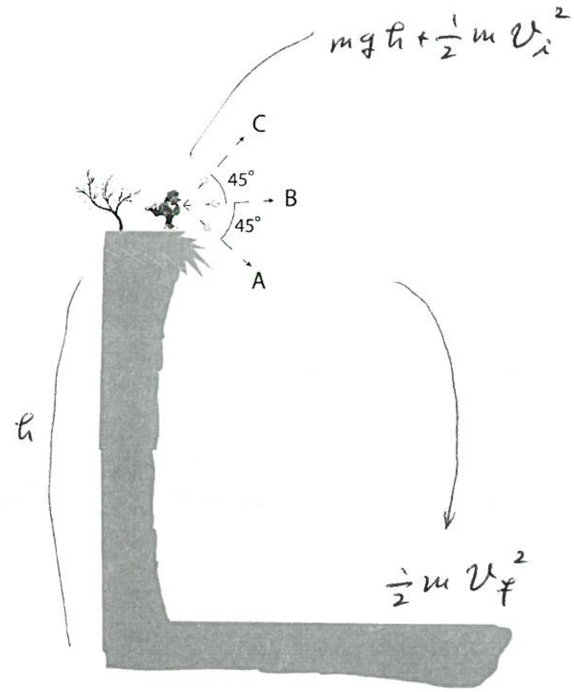
(11) Three balls of equal mass m are projected from the top of a cliff with the same speed in different directions, as shown in the figure. Air resistance is neglected. Rank A, B and C using the marks, <, > and = in order of increasing speed when the balls hit the ground.



(11) Answer

A = B = C

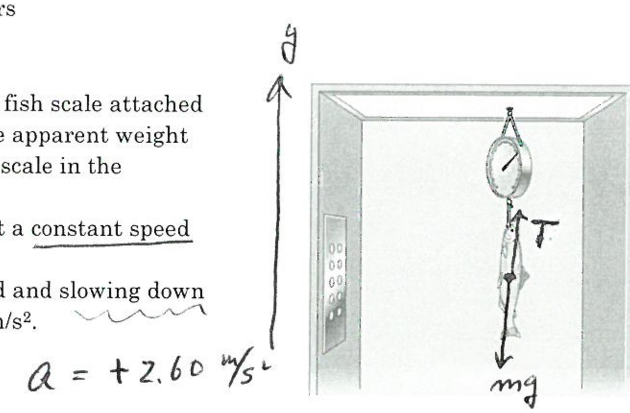
(46 %)

(12) A 5.55 kg salmon is hanged from a fish scale attached to the ceiling of an elevator. What is the apparent weight of the salmon by kg as indicated by the scale in the following conditions?

(12-a) The elevator is moving upward at a constant speed of 6.5 m/s.

(12-b) The elevator is moving downward and slowing down at a constant acceleration rate of 2.60 m/s².

(Equations)



$$\Sigma F = ma$$

$$T - mg = ma$$

(a) $a = 0$ (constant speed)

$$T - mg = 0 \rightarrow T = mg$$

$$\frac{T}{g} = m = 5.55\ (kg)$$

(b) $T = m(g + a)$

$$= 5.55\,(9.80 + 2.60)$$

$$= 68.82\ (N)$$

$$\frac{T}{g} = \frac{68.82}{9.80} = 7.022 \rightarrow 7.02\ (kg)$$

(12-a) Answer	5.55 kg
(12-b) Answer	7.02 kg

(52 %)

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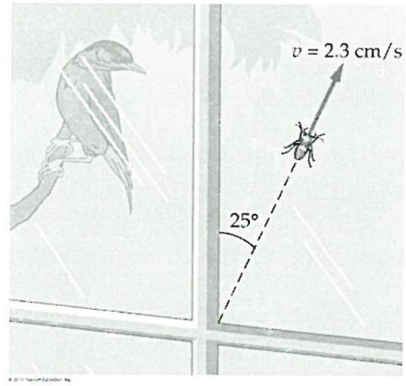
(13) Calculate the power output of 1.8-g spider as it walks up a windowpane at 2.3 cm/s on a path that is at 25° from the vertical, as illustrated in the figure.



(Equations)

$$F = mg$$

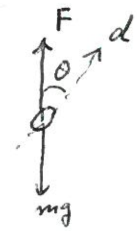
$$P = \frac{W}{t} = \frac{Fd\cos\theta}{t} = Fv\cos\theta$$

$$= mg \cdot v\cos\theta$$

$$= 1.8\times10^{-3} \times 9.80 \times 2.3\times10^{-2} \cos 25°$$

$$= 36.77\times10^{-5}$$

$$= 3.677\times10^{-4} \longrightarrow 3.7\times10^{-4} \text{ (W)}$$



(13) Answer

3.7×10^{-4} W

(17%)

(14) What temperature change is required to change the length of a 7.7-m steel beam by 0.0012 m?
(The coefficient of thermal expansion of steel: 12 x 10^{-6} K^{-1})

(Equations)

$$\Delta L = \alpha L_i \Delta T$$

$$\Delta T = \frac{\Delta L}{\alpha L_i} = \frac{0.0012}{12\times10^{-6} \times 7.7}$$

$$= 12.99 \longrightarrow 13 \text{ °C}$$

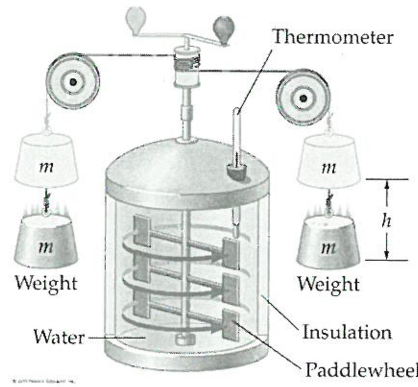
(14) Answer

13 °C

(75%)

13 K

(15) The figure at the right shows the apparatus Joule used in his experiments on the mechanical equivlent of heat. Suppose both blocks have a mass of 9.5 kg and that they fall through a distance of 1.9 m. Find the expected rise in temperature of the 330 g water.
Equations



$U = 2mgh$

$= 2 \times 9.80 \times 1.9$

$= 353.8$ (J)

$U = Q \qquad Q = mc\Delta T$

$Q = 0.330 \times 4186\, \Delta T$

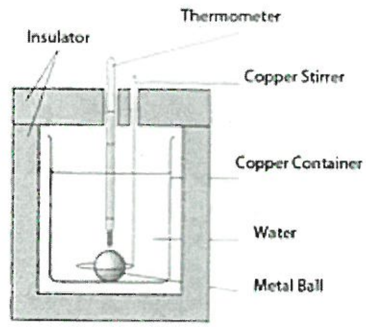
$\Delta T = \dfrac{353.8}{0.330 \times 4186}$

$= 0.256 \longrightarrow 0.26\,^\circ C$

(15) Answer
$0.26\,^\circ C$

(36 %)

(16)) In the calorimeter as shown, the total weight of copper container and copper is 130.g. When a 100. g block of metal with an initial temperature of 98.0℃ is dropped into a the container holding 200. g of water at 20.0℃, the final equilibrium temperature becomes 25.2℃. What is the specific heat of the metal?
(Equations)



Cu	130 g	20.0°C
metal	100	98.0°C
water	200	20.0°C

$$Q_{cu} + Q_{metal} + Q_{water} = 0$$

$$Q = mc\Delta T$$

$$Q_{cu} = 0.13 \times 387 \, (25.2 - 20) = \overline{26}1.6 \quad (\text{2 digits})$$

(25.2 − 20 = 5.2)

$$Q_{metal} = 0.1 \times c \, (25.2 - 98.0) = -7.28\,c$$

$$Q_{water} = 0.2 \times 4186 \, (25.2 - 20) = \overline{43}53 \quad (\text{2 digits})$$

$$\overline{43}53 + \overline{26}1.6 - 7.28\,c = 0$$

$$\overline{46}15.1 - 7.28\,c = 0$$

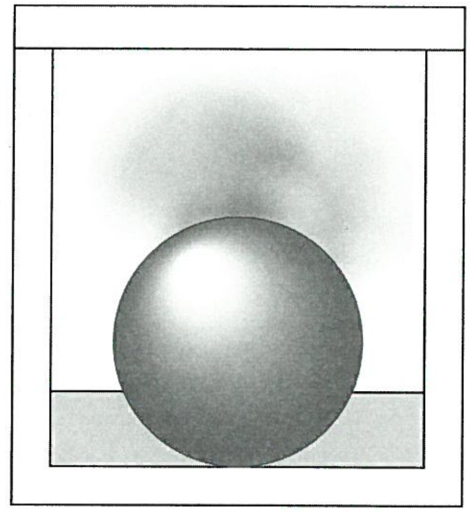
$$c = \frac{4615.1}{7.28} = 633.9 \longrightarrow 630 \ (J/kg \cdot ℃)$$

(16) Answer
630 J/kg·℃

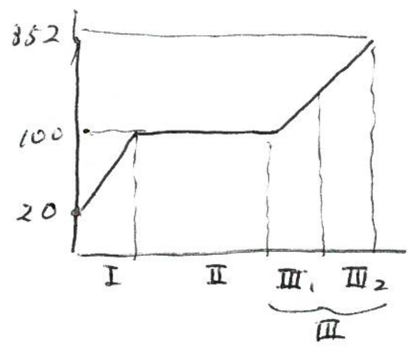
(34%)

1/23/2019 By Tohei Moritani..

(17) An 825-g iron block is heated to 352℃ and placed in an insulated container (of negligible heat capacity) containing 40.0 g of water at 20.0℃. What is the equilibrium temperature of this system? If your answer is 100℃, determine the amount of water that has vaporized. The average specific heat of iron over this temperature range is 560 J/(kg・℃).



(Equations)



Water ($20° \to 100°$) $Q_I = mc\Delta T = 0.04 \times 4186(100-20) = 13,395$

Water ($100° \to 100°$ steam) $Q_{II} = mL_v = 0.04 \times 22.6 \times 10^5 = 90,400$

$Q_I + Q_{II} = 13,395 + 90,400 = 103,795$

Iron ($352° \to 100°$) $Q_{III} = mc\Delta T = 0.825 \times 560(100-352) = -116,424$

$Q_I + Q_{II} + Q_{III} = 103,795 - 116,424 < 0$

Water ($100°$ steam $\to T$) $Q_{III-1} = mc\Delta T = 0.04 \times 2010(T-100)$
$= 80.4T - 8040$

Iron ($352° \to T$) $Q_{III-2} = mc\Delta T = 0.825 \times 560(T-352)$
$= 462T - 162,624$

I + II + III-1 + III-2

$542.4T - 66869 = 0$

$T = \dfrac{66869}{542.4} = 123.3$

$\to 123°C$

(17) Answer

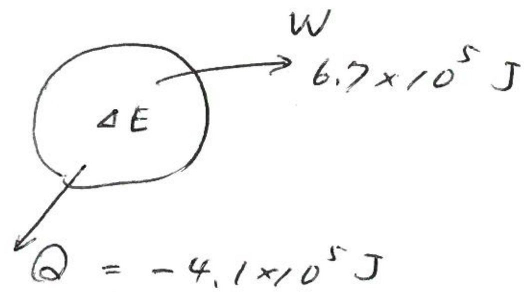
123°C

(19%)

1/23/2019 By Tohei Moritani..

(18) A swimmer does 6.7 x 10^5 J of work and gives off 4.1 x 10^5 J of heat during a workout. Determine ΔE, W and Q for the swimmer.

(Equations)



$$\Delta E = Q - W$$
$$= (-4.1 - 6.7)\times10^5$$
$$= -10.8\times10^5$$
$$= -1.08\times10^6$$

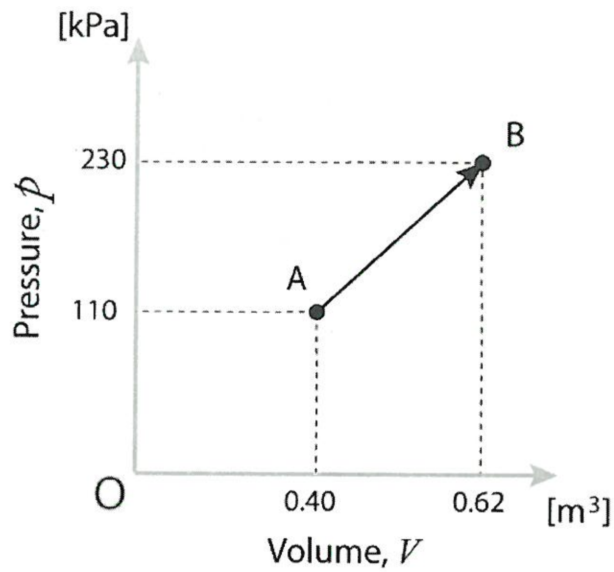
(18) Answer	
ΔE	-1.08×10^6 J
W	6.7×10^5 J
Q	-4.1×10^5 J

(34%)

2 answers correct +3

missing J −1

(19) Find the work done by a monatomic ideal gas as it expands from point A to point B along the path shown in the figure.
(Equations)



$W = (\text{area})$

$= (230 + 110) \times 10^3 \times (0.62 - 0.40) \times \frac{1}{2}$

$= 340 \times 10^3 \times 0.22 \times \frac{1}{2}$

$= 37.4 \times 10^3$

$= 3.74 \times 10^4 \longrightarrow 3.7 \times 10^4$ (J)

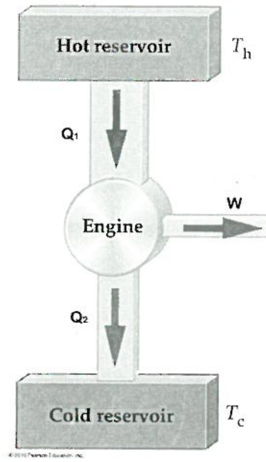
(19) Answer
3.7×10^4 J

(25%)

(20)

(20-a) An engine receives 690 J of heat from a hot reservoir and gives off 430 J of heat to a cold reservoir. What are the work done and the efficiency of this engine?

(20-b) A Carnot engine operates between the temperatures Th = 410 K and Tc = 260 K. This engine produces W = 2500 J of work. Find the heat given to the engine Qh and the heat discarded Qc. (Equations)



(a)

$$W = 690 - 430 = 260$$

$$e = \frac{W}{Q_h} = \frac{260}{690} = 0.377 \rightarrow 0.38$$

(b)

$$e = 1 - \frac{T_c}{T_h} = \frac{W}{Q_h}$$

$$Q_h = \frac{W}{1 - \frac{T_c}{T_h}} = \frac{2500}{1 - \frac{260}{410}} = 6833 \rightarrow 6800$$

$$Q_c = Q_h - W = 6833 - 2500 = 4333 \rightarrow 4300$$

	(20-a) Answer Work	260 J
0.377	Efficiency	0.38
	(20-b) Answer	
6830 J	Qh	6800 J
4330 J	Qc	4300 J

(51%)

1/23/2019 By Tohei Moritani..

(21) Recently, students performed to make cloud inside a PET bottle. A student attached a pump tool on the mouth of the bottle including a small amount of water, pumped it about 30 times and then quickly removed the pump. You found cloud generated inside the bottle. Explain how it happens using some equations of thermodynamics.

(21) Answer (in English or Japanese)

The gas inside the bottle expands very quickly and then the work of expansion occurs adiabatically (断熱的に). Then $Q = 0$

From the 1st law of thermodyamics, $\Delta E = Q - W$, $\Delta E = -W$. $W > 0$ then $\Delta E < 0$

The decrease in E or internal energy means the decrease of temperature inside the bottle. The rapid decrease in temperature causes cloud.

(12%)