Energy Transformations 2: E_k, E_{pg} and Q

1. A. Sample 2. Higher average K $\Rightarrow$ higher temperature.

   B. Sample 1. Although average $\bar{K}_1$ is only $\frac{1}{2}\bar{K}_2$, sample 1 has 10X as many molecules, so its total energy is higher.

   C. Thermal energy would flow from 2 $\longrightarrow$ 1. Thermal energy always flows from high TEMP to low TEMP (hot $\rightarrow$ cold)

2. A

3. C

4. E

5. $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(4kg)(10\,m/s)^2 = 200\,J$

6. $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(2kg)(8\,m/s)^2 = 64\,J$

7. $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(6kg)(4\,m/s)^2 = 48\,J$

8. $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(800kg)(0.5\,m/s)^2 = 100\,J$

9. $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(0.250kg)(2\,m/s)^2 = 0.5\,J$

10. $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(0.400kg)(13\,m/s)^2 = 33.8\,J$

11. $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(1000kg)(20\,m/s)^2 = 200\,000\,J$

    $* \; 72\,\frac{km}{h} \times \left(\frac{1000m}{km}\right) \times \left(\frac{1h}{60min}\right) \times \left(\frac{1min}{60s}\right) = 20\,m/s$

12. $E_k = \frac{1}{2}mv^2 \Rightarrow 148J = \frac{1}{2}(74kg)v^2 \Rightarrow 4 = v^2$

    $\Rightarrow 148J = 37kg\,v^2$

    $\Rightarrow \frac{148J}{37kg} = v^2$

    $v = 2\,m/s$

13. $m = 0.600\,kg$

$E_k = \frac{1}{2}mv^2 \Rightarrow 16 = \frac{1}{2}0.6v^2$

$\Rightarrow 16 = 0.3v^2$

$\Rightarrow 53.\bar{3} = v^2$

$v = 7.3\,m/s$

14. $E_{pg} = mgh = 2.0kg(9.8\,m/s^2)(5m) = 98J$

15. $E_{pg} = mgh = 12kg(9.80\,m/s^2)(1.3m) = 152.88J$

16. $m = 0.666kg$

$E_{pg} = mgh = 0.666kg(9.8\,m/s^2)(666m) = 4346.8488J \simeq 4350J$

17. $E_{pg} = mgh \Rightarrow 666J = 0.666kg(9.8)h$

$\Rightarrow h = \frac{666}{0.666(9.8)} = 102.04\ldots \simeq 102m$

18. $E_{pg} = mgh \Rightarrow 666J = m(9.8\,m/s^2)(6.66m)$

$\Rightarrow m = \frac{666J}{6.66(9.8)} = 10.204\ldots \simeq 10.2kg$

19.

	E_k	E_{pg}	E_T
A	13 J	27 J	40J
B	11 J	29J	40J
C	8 J	32J	40J
D	19J	21J	40J
E	36J	4J	40J

20. A. $E_k = \frac{1}{2}mv^2 \Rightarrow 8 = \frac{1}{2}(0.250)v^2$

$64 = v^2$

$v = 8\,m/s$

B. $E_{pg} = mgh \Rightarrow 21 = 0.25(9.8)h$

$h = 8.57142857 \simeq 8.6\,m$

C. $E_k = \frac{1}{2}mv^2 \Rightarrow 36 = \frac{1}{2}(0.25)v^2$

$288 = v^2$

$v = 16.970\ldots \simeq 17\,m/s$

D. $E_{pg} = mgh \Rightarrow 29 = 0.250(9.8)h$

$h = 11.836\ldots \simeq 12\,m$

21. $Q = mc\Delta T \Rightarrow 20\,000\,J = 2\,kg\,c\,(50°C)$

$c = 200\,J/kg°C$

22. $Q = mc\Delta T \Rightarrow 20\,000\,J = 2\,kg\,c\,(79°C - 29°C)$

$c = 200\,J/kg°C$

23A. $Q = mc\Delta T = 0.2\,kg(4200\,J/kg°C)(100°C - 20°C) = 67\,200\,J$

B. $Q = mL_v = 0.2\,kg(2300\,000\,J/kg) = 460\,000\,J$

C. $Q = mc\Delta T = 0.2\,kg(2200\,J/kg°C)(150°C - 100°C) = 22\,000\,J$

D. $Q_T = Q_A + Q_B + Q_C = 67\,200\,J + 460\,000\,J + 22\,000\,J = 549\,200\,J$

549 200 J

24. A. $Q = mc\Delta T = 0.2kg(2200 \frac{J}{kg°C})(100°C - 150°C) = -22000\,J \Rightarrow$ 22 000 J released

B. $Q = -mL_v = -0.2kg(2\,300\,000 \frac{J}{kg}) = -460\,000\,J \Rightarrow$ 460 000 J released

C. $Q = mc\Delta T = 0.2kg(4200 \frac{J}{kg°C})(20°C - 100°C) = -67\,200\,J \Rightarrow$ 67 200 J released

D. $Q_T = Q_A + Q_B + Q_C = -549\,200\,J \Rightarrow$ 549 200 J released

25. From 20°C to -30°C it is liquid.

A. $Q = mc\Delta T = 1.2kg(2300 \frac{J}{kg°C})(-30°C - 20°C) = -138\,000\,J$
$= 138\,000\,J$ removed

B. $Q = mc\Delta T = 1.2kg(2300 \frac{J}{kg°C})(78°C - 20°C) = 160\,080\,J$

C. $Q = -mL_f = -1.2kg(110\,000 \frac{J}{kg}) = -132\,000\,J \Rightarrow$ 132 000 J removed

D. $Q = mc_l\Delta T_l + (-mL_v) + mc_g\Delta T_g + (-mL_f) + mc_s\Delta T_s$

$= 1.2(1800)(78°C - 100°C) - 1.2(850\,000) + 1.2(2300)(-114 - (-78)) - 1.2(110\,000) + 1.2(970)(-120 - (-114))$

$= -1\,736\,424\,J$

$\Rightarrow$ 1 736 424 J removed

26. The energy lost by the aluminum is gained by the water!

$$-Q_A = Q_W$$

$$-m_A c_A \Delta T_A = m_W c_W \Delta T_W$$

$$-0.06(900)(T - 460) = 1.5(4200)(T - 12.4)$$

$$-54T + 24840 = 6300T - 78120$$

$$102\,960 = 6354T$$

$$16.2°C = T$$

27. Energy lost by copper = Energy gained by water

$$-Q_{Cu} = Q_w$$

$$-mc_c\Delta T_c = m_w c_w \Delta T_w$$

$$-0.12kg(390)(T-250) = 1.4(4200)(T-36.3)$$

$$-46.8T + 11700 = 5880T - 213444$$

$$225144 = 5926.8T$$

$$T = 37.9874...$$

$$\underline{T = 38.0°C}$$

28. Energy lost by lead = Energy gained by water

$$-Q_L = Q_w \qquad 2000L \times \left(\frac{1kg}{L}\right) = 2000kg$$

$$-m_L c_L \Delta T_L = m_w c_w \Delta T_w$$

$$-29(130)(T-800) = 2000kg(4200)(T-75°C)$$

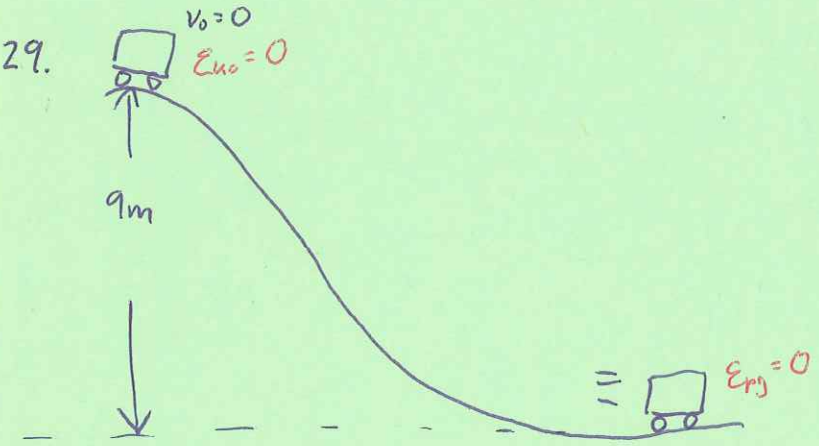
$$-3770T + 3016000 = 8400000T - 6.3\times10^8$$

$$6.33016\times10^8 = 8.40377\times10^6 T$$

$$T = 75.3252409°C$$

$$\underline{T = 75.3°C}$$

29.



$$\mathcal{E}_T = \mathcal{E}_{T0}$$

$$\mathcal{E}_k + \cancel{\mathcal{E}_{pg}}^{0} = \cancel{\mathcal{E}_{k0}}^{0} + \mathcal{E}_{pg0}$$

$$\mathcal{E}_k = mgh_0$$

$$\mathcal{E}_k = 150kg(9.8\,m/s^2)(9m)$$

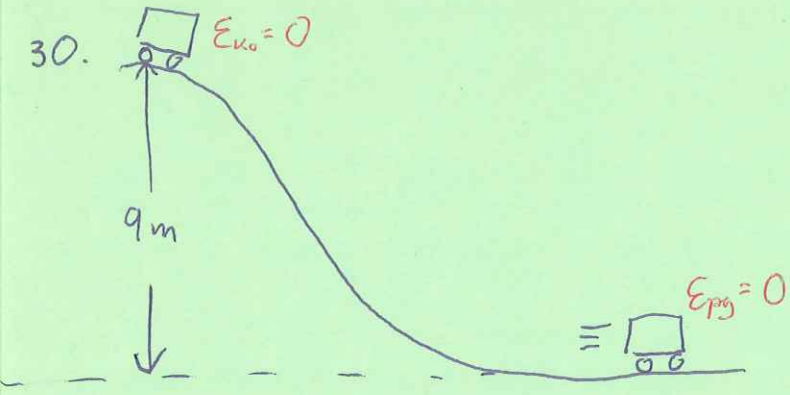
$$\mathcal{E}_k = 13230J$$

$$\frac{1}{2}mv^2 = 13230J$$

$$\frac{1}{2}150v^2 = 13230J$$

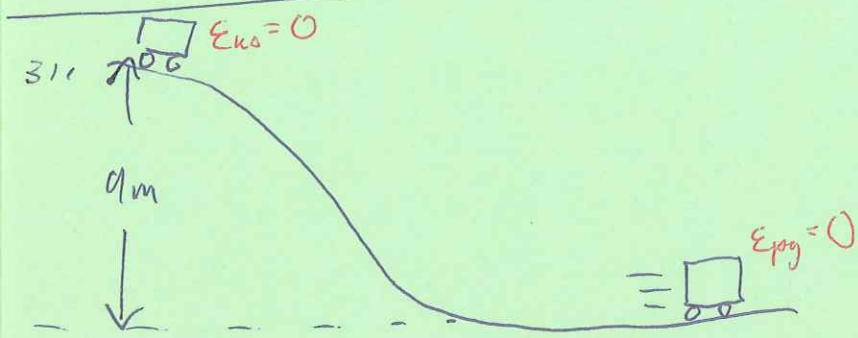
$$\underline{v = 13.3\,m/s}$$

30.



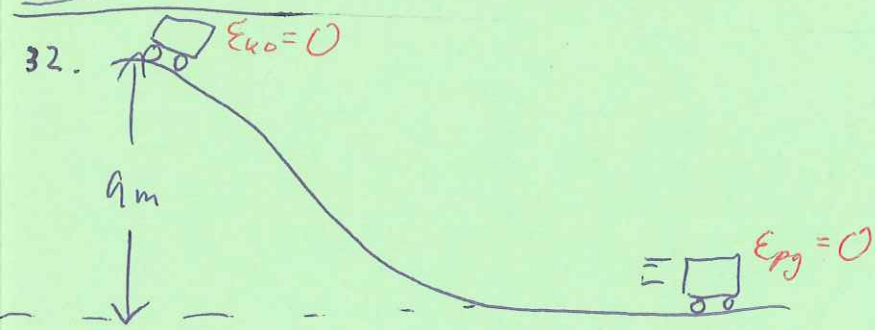
$$E_T = E_{T0}$$
$$E_k + \cancel{E_{pg}}^{0} = \cancel{E_{k0}}^{0} + E_{pg0}$$
$$\tfrac{1}{2}mv^2 = mgh_0$$
$$\tfrac{1}{2}250v^2 = 250(9.8)(9)$$
$$125v^2 = 22050$$
$$v^2 = 176.4$$
$$v = 13.3\ m/s$$

31.



$$E_T = E_{T0}$$
$$E_k + \cancel{E_{pg}}^{0} = \cancel{E_{k0}}^{0} + E_{pg0}$$
$$\tfrac{1}{2}\cancel{m}v^2 = \cancel{m}gh_0$$
$$\tfrac{1}{2}v^2 = 88.2$$
$$v^2 = 176.4$$
$$v = 13.3\ m/s$$

32.



$$E_T = E_{T0}$$
$$E_k + \cancel{E_{pg}}^{0} = \cancel{E_{k0}}^{0} + E_{pg0}$$
$$\tfrac{1}{2}\cancel{m}v^2 = \cancel{m}gh_0$$
$$v^2 = 2gh_0$$
$$v = \sqrt{2gh_0}$$
$$v = 13.3\ m/s$$

* Hopefully you noticed that the mass did not affect the final answer. I showed the work in slightly different ways to show that the exact way you do your algebra (i.e. sub numbers in first, do algebra first ...) does not affect the result.

33. D, E 34. B 35. D 36. A, C, E 38. L_f

39. $C_l < C_s < C_g$