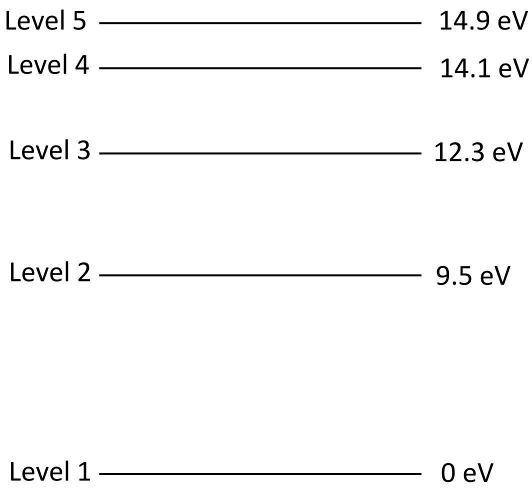
Republic Polytechnic

A107 Physics

Problem Review Part 4 (P11-P13) – Practice Questions

1) The diagram below shows the energy levels of an atom.



a. What is the amount of energy required for an electron to transit from level 1 to level 4?

b. What is the energy of the photon emitted when an electron drop from level 4 to level 2?

c. What is the frequency of the photon emitted in part b?

d. What is the wavelength of the photon emitted in part b?

a) 14.1 eV

b) 14.1 eV – 9.5 eV = 4.6 eV

c) Since $E = hf$

➔ 4.6 eV = $4.14 \times 10^{-15} \times f$

➔ $f = 4.6 / (4.14 \times 10^{-15})$

➔ $f = 1.11 \times 10^{15}$ Hz

d) Since $f\lambda = c$

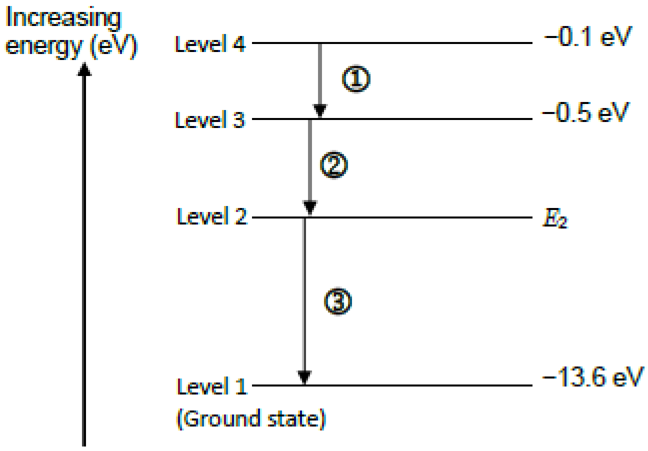
we have $1.11 \times 10^{15} \times \lambda = 3 \times 10^{8}$

Thus, $\lambda = (3 \times 10^{8}) / (1.11 \times 10^{15})$

$= 2.703 \times 10^{-7}$ m

We can convert to nm if we want, which is 270.3×10^{-9} m which is 270.3 nm

2) The figure below shows the energy levels of an atom.



An electron drops down from level 4 to level 1 through the 3 stages ①, ② and ③ as shown. Three photons were emitted (each from the respective stages). Taking h = 4.14 × 10-15 eV.s and c = 3 × 10^8 m/s,

a) Determine the sum of the energy of the 3 photons.

The sum of energy of the 3 photons is simply $E4 - E1 = -0.1 - (-13.6) = 13.5$ eV.

b) Given that the frequency of the photon emitted from stage ② is 1.5 × 10^{15} Hz, determine the energy of this photon in eV.

$E = hf$

$E = 4.14 \times 10^{-15} \times 1.5 \times 10^{15} = 6.21$ eV

c) Hence, using your answer in part (b), determine the energy level $E2$ at level 2.
Since energy of photon emitted in stage 2 is 6.21 eV .$E3 – E2$ = 6.21 eV and $E3$ = −0.5 eV
−0.5 eV − $E2$ = 6.21 eV $E2$ = −0.5 eV – 6.21 eV $E2$ = −6.71 eV

3) 40000 J is required to heat up the temperature of 5 kg of material A from 30°C to 40°C. Determine the specific capacity of the material.

$Q = mc\Delta T$
40000 = 5 x c x (40-30)
40000 = 50 C
c = 800 J/ kg °C

4) The heating coil in a water tank is known to operate at 110 V. Calculate the resistance of the heating coil when the coil is used to heat up 20 kg of water from 20 °C to 80 °C within a time period of 30 minutes. (Specific heat capacity of water is 4200 J kg^{-1} K^{-1})

Rate of energy delivered to the coil = rate of heat gain by water
But rate of energy delivered to coil is the power (P)

P (= VI = V^2/R) = Q/t where P is power, V is voltage, R is resistance, Q is the amount of heat gained by the water and t is time.

But $Q = mc\Delta T$

$R = (V^2t) / mc\Delta$)

$R = (110^2 \times 30 \times 60) / (20 \times 4200 \times \{80 - 20\})$

= 4.32 Ω

5) The following two quantities of water are mixed together:

- 3 kg of water at 40°C
- 5 kg of water at 80°C

What is the final temperature of the 8 kg water?
[Note: Specific heat capacity of water is 4200 J/kg °C]

Heat gain by the cooler water = Heat loss by the hotter water

$3 \times 4200 \times (T - 40) = 5 \times 4200 \times (80 - T)$

$3T - 120 = 400 - 5T$

$3T + 5T = 120 + 400$

$T = 65°C$

6) Solid ice (50 g) was added to a glass of water (800 g) which was initially at 25ºC. Calculate the equilibrium temperature of the mixture. (Specific heat capacity of water = 4.19 J/g·ºC and specific latent heat of fusion = 334 J/g)

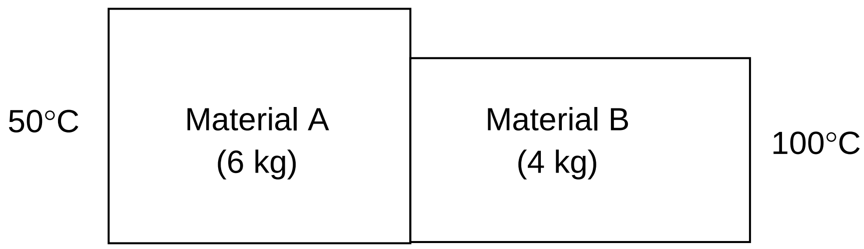
Heat lost by water = Heat gained during melting of ice + Heat gained with increase in temperature of ice water

800(4.19)(25 - T) J = 50(334) J + 50(4.19)(T - 0) J

83800- 3352 T = 16700 + 209.5 T

T = 18.84°C

7) The specific capacity of material A is 800 J/kg °C
The specific capacity of material B is 1200 J/kg °C
A 6 kg block of material A at temperature 50°C is in thermal contact with a 4 kg block of material B at temperature 100°C, what is the final temperature of the blocks when they reach thermal equilibrium.



Heat gain by the cooler block = Heat loss by the hotter block

$6 \times 800 \times (T - 50) = 4 \times 1200 \times (100 - T)$

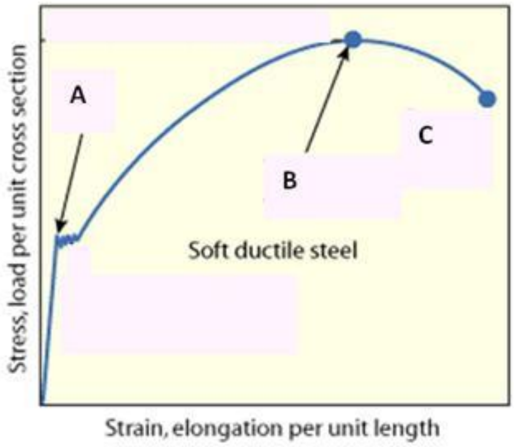
$4800 \times (T - 50) = 4800 \times (100 - T)$

$T - 50 = 100 - T$

$2T = 150$

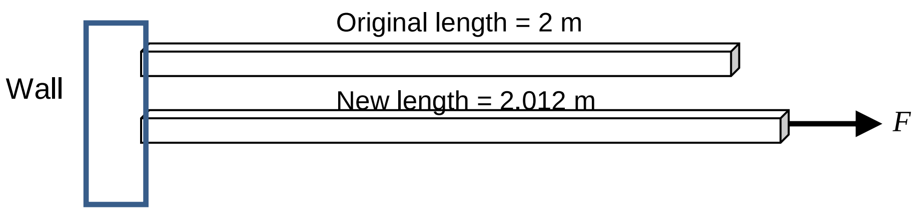
T = 75°C

8) The following figure shows the stress-strain characteristics of ductile steel. Which of the point (A, B or C) is most likely to be the elastic limit of this material?



Solution: A is proportional limit but in this case is also the elastic limit.

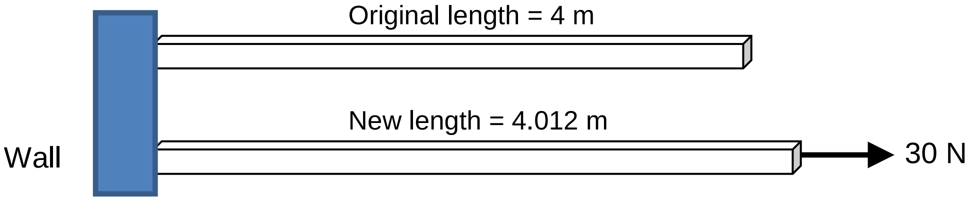
9) The diagram below show a force being exerted on pole causing it to extend.



Determine the strain on the pole.

Solution:
Strain = Change in length / Original Length
Change in length = 2.012 m – 2 m = 0.012 m
Strain = 0.012 m / 2m = 0.006
There is no units for strain.

10) The diagram below show a force of 30 N being exerted on pole causing it to extends its length to become longer. The cross-sectional area of the pole is 0.0005 m^3.



a) Determine the stress on the pole.

Stress = tension / cross-sectional area = 30 / 0.0005 = 60000 Pa

b) Determine the strain on the pole.

Strain = change in length / original length = 0.012 / 4 = 0.003

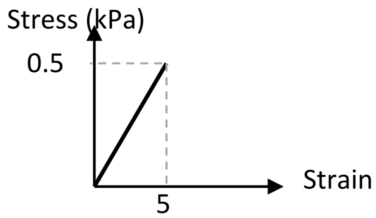
c) Determine the Young's modulus of the material of the pole

Young's Modulus = Stress / Strain = 60000/0.003 = 20 000 000 Pa

d) If the cross-sectional area of the pole is doubled to 0.0010 m^2, what would be the Young's Modulus of the material of the pole?

20 000 000 Pa; Young's Modulus is independent of the shape or size and depends on the material itself.

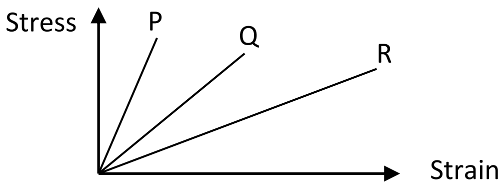
11) The diagram below shows the stress-strain graph of a material.



Determine the Young's Modulus of this material.

Solution:
The Young's Modulus can be determined by the gradient on the stress-strain graph.
Young Modulus = 0.5 × 1000 / 5 = 100 Pa

12) The diagram below shows the stress-strain graph of three materials P, Q and R.



Which material is the stiffest and which material is the most flexible? Explain your answer.

Answer:

P is the stiffest material, because its gradient is the steepest. The Young’s Modulus is represented by the gradient on the stress-strain graph. A material having a high Young’s Modulus is stiff.

R is the most flexible, because its gradient is the lowest. A material having a low Young’s Modulus is more flexible.

