# PHYS 143 TEST 3 24.4.2018

1. A main water pipe with a 2.5 cm inner diameter carries water into a house at a speed of 0.9 m/s and a pressure of 190 kPa. Inside the house the pipes have a 1.2 cm inner diameter. What is the speed of water inside the house?

A) 1.9 m/s
B) 0.9 m/s
C) 3.9 m/s
D) 2.6 m/s
E) 0.21 m/s

$v_1 A_1 = v_2 A_2$

$(0.9)\frac{\pi (2.5)^2}{4} = v_2 \frac{\pi (1.2)^2}{4}$

$v_2 = (0.9)\left(\frac{2.5}{1.2}\right)^2 = 3.9 \text{ m/s}$

2. In Problem 1 above what is the water pressure in the third floor of the house 7.6 m above the main pipe?

A) 108 kPa
B) 183 kPa
C) 190 kPa
D) 175 kPa
E) 115 kPa

$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$

$P_2 = P_1 + \rho g h_1 - \rho g h_2 + \frac{1}{2}\rho v_1^2 - \frac{1}{2}\rho v_2^2$

$= 190\times10^3 + 0 - 1000(9.8)(7.6) + \frac{1}{2}(1000)(0.9)^2 - \frac{1}{2}(1000)(3.9)^2$

$= 190{,}000 + 0 - 74{,}480 + 405 - 7605 = 108{,}320 \text{ Pa}$

3. A man has his artery severed in an accident. If the artery has a diameter of 7 mm and blood flows out of it with a velocity of 1.2 m/s, how much blood does the man lose in 10 seconds?

A) 1800 cm$^3$
B) 920 cm$^3$
C) 92 cm$^3$
D) 460 cm$^3$
E) 46 cm$^3$

Volume of blood lost $= v A \Delta t$

$= (1.2 \text{ m/s})\cdot\pi\left(\frac{7}{2}\times10^{-3} \text{ m}\right)^2 \cdot 10s$

$= 46\times10^{-5} \text{ m}^3 = 460 \text{ cm}^3$

$1 \text{ m}^3 = (100 \text{ cm})^3 = 10^6 \text{ cm}^3$

4. If the artery in Problem 3 is not severed but instead 100 capillaries are severed. How much blood does the man lose in 10 seconds? The diameter of a capillary is about 7 μm and blood flows out of it with a velocity of 1.2 m/s,

A) 0.18 cm$^3$
B) 0.092 cm$^3$
C) 0.046 cm$^3$
D) 0.0046 cm$^3$
E) 0.0092 cm$^3$

Volume lost $= (100)\, v A' \Delta t$

$= (100)(1.2 \text{ m/s})\left(\frac{7\times10^{-6}}{2}\right)^2 \pi \cdot 10s$

$= (460 \text{ cm}^3)\times100\times10^{-6} = 0.0460 \text{ cm}^3$

5. A liter (1000 cm$^3$) of water at 20□ C fills a glass bottle up to the beginning of its neck (عنق). If the liter of water is heated to 50□ C and then poured into the same bottle how much does the water rise in the neck. The volume expansion coefficient of water is $2.1\times10^{-4}$ K$^{-1}$ and the inner diameter of the neck is 2.0 cm. Assume that the expansion of the glass bottle is negligible.

A) 2.0 cm
B) 0.50 cm
C) 1.0 cm
D) 0.20 cm
E) 0.10 cm

$\Delta V = V_0 \beta \Delta T = (1000)(2.1\times10^{-4})(30) = 6.3 \text{ cm}^3$

$\Delta h = \frac{\Delta V}{A} = \frac{6.3 \text{ cm}^3}{\pi (1.0 \text{ cm})^2} \approx 2.0 \text{ cm}$

Use $g = 9.8$ m/s$^2$.

6. Which of the following statements is true:

A) Liquid-filled thermometers contain a liquid whose volume is fixed. False. Liquid expands
B) A bi-metallic strip consists of 2 freely moving strips. False. Strips are soldered together
(C) The density of water at 1□ C is slightly lower than its density at 3□ C. True. $\rho_{max}$ at 4°C.
D) We can use a gas of any density inside a constant-volume gas thermometer. False: low density gas
E) In a lake whose surface is frozen the coldest water is found at the lake's bottom. False: at bottom T=4°C

7. A steel cube of side 3 cm is placed inside a glass cylinder of inner cross-sectional area of 20 $cm^2$. Water is then poured in the cylinder so that the top of the water is at a height of 5 cm above the cylinder's base. If the water and steel temperature increases by 30 K, by how much does the water surface rise? Assume that the expansion of the glass cylinder is negligible. Take the volume expansion coefficient of water is $2.1\times10^{-4}$ $K^{-1}$ and $\alpha = 12\times10^{-6}$ $K^{-1}$ for steel.

$V_{total} = (20\ cm^2)(5\ cm) = 100\ cm^3$

A) 0.32 mm
(B) 0.24 mm
C) 0.36 mm
D) 0.16 mm
E) 0.40 mm

$V_{cube} = (3\ cm)^3 = 27\ cm^3 \Rightarrow V_{water} = 100 - 27 = 73\ cm^3$

$\Delta V_{cube} = (27)(3\alpha)\Delta T = 0.02916\ cm^3$

$\Delta V_{water} = (73)(2.1\times10^{-4})\times 30 = 0.4599\ cm^3$

$\Delta V_{Total} = 0.48906\ cm^3$

$\Delta h = \Delta V / A$
$= 0.0244\ cm$
$\approx 0.24\ mm$

8. You drink 400 $cm^3$ of cold water (at 10□ C). Calculate the increase in the water volume once it reaches the core body temperature in your stomach? Take $\beta = 2.0\times10^{-4}$ $K^{-1}$.

$\Delta V = V_0\ \beta\ \Delta T$
$= (400)(2.0\times10^{-4})(27) = 2.2\ cm^3$

A) 0.22 $cm^3$
(B) 2.2 $cm^3$
C) 3.0 $cm^3$
D) 0.30 $cm^3$
E) 1.0 $cm^3$

9. Ten ants are placed at the center of a room. After 1 minute their displacements are as follows:

| Number of ants | 1 | 1 | 2 | 2 | 3 | 1 |
|---|---|---|---|---|---|---|
| Displacement (cm) | 6 | 10 | 14 | 16 | 20 | 30 |

Calculate their rms displacement.

$d_{rms} = \sqrt{[6^2 + 10^2 + 2(14)^2 + 2(16)^2 + 3(20)^2 + (30)^2]/10}$
$= \sqrt{3140/10} = 17.7\ cm \approx 18\ cm.$

A) 10 cm
B) 8.0 cm
C) 24 cm
(D) 18 cm
E) 13 cm

10. The diffusion constant of the ants in Problem 9 is:

$d_{rms} = \sqrt{2Dt}$

$D = \frac{d_{rms}^2}{2t} = \frac{314\ cm^2}{(2)(60s)} = 2.61\ cm^2/s$
$= 2.61\times10^{-4}\ m^2/s$

A) $2.6\times10^{-4}$ m/s
B) 2.6 $m^2/s$
C) 2.6 m/s
D) 2.6 cm/s
(E) $2.6\times10^{-4}$ $m^2/s$

Use $g = 9.8\ m/s^2$.

11. A semi-permeable membrane divides the 2 arms of a U-tube at the bottom. The right arm of the tube has pure water and the left arm has a solution in water. At equilibrium the height of the solution in the left arm is 15 cm and the height of water in the right arm is10 cm. Calculate the osmotic pressure of the solution. Assume that water and the solution have the same density.

A) 1470 Pa
B) 980 Pa
C) 147 Pa
D) 98 Pa
E) 490 Pa

$P = \rho g \Delta h = 1000\,(9.8)\,(0.05\ m)$
$= 490\ Pa$

12. A water cylinder 10 cm long contains oxygen in solution. At the left end of the cylinder, the concentration of oxygen is maintained at 0.30 mol $m^{-3}$ and falls off linearly to 0.10 mol $m^{-3}$ at the right end. What is the concentration gradient of oxygen inside the cylinder?

A) 2.0 $mol/m^4$
B) -2.0 $mol/m^4$
C) 2.0 $mol/m^3$
D) -2.0 $mol/m^3$
E) 2.0 mol/m

$\frac{\Delta C}{\Delta x} = \frac{(0.10) - (0.30)\ mol.\ m^{-3}}{0.10\ m}$
$= -2\ mol\,m^{-4}$

13. Which of the following statements is true?

A) The cornea receives its oxygen from the blood supplied to it. False: cornea has no blood supply
B) In reverse osmosis the molecules of the solute move through the semipermeable membrane. False
C) Oxygen diffuses into the blood stream through the alveoli walls. True
D) The size of spherical aerobic bacteria is limited by the diffusion constant of $O_2$ in water. True
E) C and D are both true. True

solute molecules cannot move through membrane.

14. The resistance of the probe of a thermistor is known to vary with temperature according to the formula R =12 Ω + (0.05 Ω □$C^{-1}$)T, where T is in □C. If the resistance is measured to be 16 Ω when the probe is inserted into an object, what is the temperature of the object?

A) 50□C
B) 60□C
C) 70□C
D) 80□C
E) 90□C

$R = 12 + 0.05\,T$
$16 = 12 + (0.05)\,T \Rightarrow T = 80^\circ C$

15. Which of the following statements is true:
A) Flux is the amount transported per unit area per unit time. True
B) The Kelvin scale is defined by the freezing and boiling points of water at standard pressure. False
C) ΔT in □C = ΔT in K - 273.15 False ΔT in °C = ΔT in K.
D) If objects A and B are in thermal equilibrium and objects A and C are in thermal equilibrium we cannot conclude that B and C are in thermal equilibrium. False
E) All the molecules of a gas have the same speed at a given constant temperature. False

Use g = 9.8 $m/s^2$.