Test 2

1.

The ideal gas (ν = 1 mol) is in a volume of V = 100 l at a temperature of T = +27 ºC.
Find the pressure P (Pa).
R = 8.31 $J\cdot mol^{-1}\cdot K^{-1}$.
*****

$V = 100\ (l) = 100\cdot10^{-3}\ (m^3) = 0.1\ (m^3)$
$T = +27\ ºC = 273 + 27\ (K) = 300\ (K)$
$P\cdot V = \nu\cdot R\cdot T$
$P = \frac{\nu\cdot R\cdot T}{V} = \frac{1\cdot8.31\cdot300}{0.1} = 24930\ (Pa)$

2.

The force F = 10 N acts on the area $A = 2\cdot10^4\ cm^2$.
Find the pressure P (Pa).
*****

$A = 2\cdot10^4\ (cm^2) = 2\cdot10^4\cdot10^{-4}\ (m^2) = 2\ (m^2)$
$P = \frac{F}{A} = \frac{10}{2} = 5\ (Pa)$

3.

Find oceanic pressure P (Pa) at depth L = 0.01 km.
The atmospheric pressure $P_0 = 10^5$ Pa.
The density of water $\rho = 1000\ kg\cdot m^{-3}$.
The standard acceleration of free fall $g = 10\ m\cdot s^{-2}$.
*****

$L = 0.01\ (km) = 0.01\cdot10^3\ (m) = 10\ (m)$
$P = P_0 + \rho\cdot g\cdot L = 10^5 + 10^3\cdot10\cdot10 = 2\cdot10^5\ (Pa)$

4.

A hydraulic lift has pistons with cross sectional areas $A_1 = 0.1\ m^2$ and $A_2 = 2\ m^2$, and supports masses m_1 = 1 kg and m_2, respectively.
Find m_2 (kg).
*****

$P_1 = P_2$
$\frac{m_1\cdot g}{A_1} = \frac{m_2\cdot g}{A_2}$
$m_2 = m_1\cdot\frac{A_2}{A_1} = 1\cdot\frac{2}{0.1} = 20\ (kg)$

5.
The syringe diameter is D_1 = 1.0 cm.
The needle diameter is D_2 = 1.0 mm.
Nurse moves plunger with speed υ_1.
Find the speed of squirt from needle υ_2.
*****

1 cm = 10 mm

$\upsilon_1 \cdot A_1 = \upsilon_2 \cdot A_2$

$A = \frac{\pi \cdot D^2}{4}$

$\upsilon_1 \cdot \frac{\pi \cdot D_1^2}{4} = \upsilon_2 \cdot \frac{\pi \cdot D_2^2}{4}$

$\upsilon_1 \cdot D_1^2 = \upsilon_2 \cdot D_2^2$

$\upsilon_2 = \upsilon_1 \cdot \left(\frac{D_1}{D_2}\right)^2 = \upsilon_1 \cdot \left(\frac{10}{1}\right)^2 = 100 \cdot \upsilon_1$

6.
Laminar fluid flow through the pipe under pressure $\Delta P = 10^6$ Pa.
The fluid viscosity η = 0.314 Pa·s.
The pipe length L = 12.5 m, the pipe radius R = 10 cm.
Find the volumetric flow rate Q ($m^3 \cdot s^{-1}$).
*****

$R = 10 \text{ (cm)} = 10 \cdot 10^{-2} = 0.1 \text{ (m)}$

$Q = \frac{\pi \cdot R^4}{8 \cdot \eta \cdot L} \cdot \Delta P = \frac{\pi \cdot 0.1^4}{8 \cdot 0.314 \cdot 12.5} \cdot 10^6 = \frac{10 \cdot 10^{-4} \cdot 10^6}{100} = 10 \ (m^3 \cdot s^{-1})$

7.
The speed of flow in a circular pipe is $\upsilon = 1 \ m \cdot s^{-1}$.
The pipe diameter D = 0.1 m.
The liquid density is $\rho = 1000 \ kg \cdot m^{-3}$.
The liquid viscosity η = 0.1 Pa·s.
Find Reynolds number Re.
*****

$Re = \frac{\rho \cdot \upsilon \cdot D}{\eta} = \frac{10^3 \cdot 1 \cdot 0.1}{0.1} = 1000$

8.
The temperature T = +50 ºC.
Find absolute temperature.
*****

T (K) = 273 + T (ºC) = 273 +50 = 323 (K)

9.
The energy is W = 5 calories.
Find energy W (J).
*****

1 cal = 4.186 J
$W = 5 \cdot 4.186 = 20.93$ (J)

10.
A gas is compressed from $V_i = 1\ m^3$ to $V_f = 0.5\ m^3$ by pressure P = 1 atm.
Find work on gas W_g (J).
*****

1 atm = 10^5 Pa
The work done **by** gas $W = P \cdot (V_f - V_i) = 10^5 \cdot (0.5 - 1) = -5 \cdot 10^4$ (J)
The work **on** gas is $W_g = -W = 5 \cdot 10^4$ (J)

11.
An system received heat Q = 10 J and did work W = 5 J.
Find the change in energy of system ΔU.
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$\Delta U = Q - W = 10 - 5 = 5$ (J)

12.
The initial pressure of ideal gas is P_i.
The volume of gas decreased by 2 times as a result of the isothermal process.
Find final pressure P_f.
*****

$P_i \cdot V_i = P_f V_f$
$P_f = \frac{P_i \cdot V_i}{V_f} = 2 \cdot P_i$

13.
A cyclic device takes heat Q_h = 10 J from hot reservoir, convert some of it to work and reject the rest of it Q_c = 2 J to cold reservoir.
Find the efficiency ϵ of heat engine (%).
*****

$\epsilon = 1 - \frac{Q_c}{Q_h} = 1 - \frac{2}{10} = 0.8 = 80\ \%$

14.
A capillary liquid height is h = 0.1 m, capillary radius is R = 1 mm.
Density of liquid is $\rho = 800\ kg\cdot m^{-3}$.
The standard acceleration of free fall $g = 10\ m\cdot s^{-2}$.
Find surface tension of liquid σ ($N\cdot m^{-1}$).
*****

$R = 1\ (mm) = 1\cdot 10^{-3}\ (m)$
$2\cdot\pi\cdot R\cdot\sigma = m\cdot g$
$m = \rho\cdot V = \rho\cdot h\cdot \pi\cdot R^2$
$\sigma = \frac{m\cdot g}{2\cdot\pi\cdot R} = \frac{\rho\cdot h\cdot \pi\cdot R^2\cdot g}{2\cdot\pi\cdot R} = \frac{\rho\cdot h\cdot R\cdot g}{2} = \frac{800\cdot 0.1\cdot 10^{-3}\cdot 10}{2} = 0.4\ (N\cdot m^{-1})$

15.
What volume V (m^3) of helium is need if a balloon is to lift a load of m = 180 kg (including the weight of empty balloon)?
Density of helium is $\rho_{He} = 0.179\ kg\cdot m^{-3}$, density of air is $\rho_{air} = 1.29\ kg\cdot m^{-3}$.
*****

Archimedes' principle
$m_{He}\cdot g + m\cdot g - \rho_{air}\cdot g\cdot V = 0$
$m_{He} = \rho_{He}\cdot V$
$\rho_{He}\cdot V + m - \rho_{air}\cdot V = 0$
$V = \frac{m}{\rho_{air}-\rho_{He}} = \frac{180}{1.29-0.179} = 162\ (m^3)$