2019

1) A

considering the units of these symbols

$\hbar = kg \cdot m^2 \cdot s^{-1}$

$m = kg$

$\varepsilon_0 = C^2 \cdot m^{-3} \cdot kg^{-1} \cdot s^2$

$e = C$

Try all options 1 by 1, for option (A)

$$\frac{me^4}{\hbar^2 \cdot \varepsilon_0^2} = \frac{kg \cdot C^4}{(kg \cdot m^2 \cdot s^{-1})^2 \cdot (C^2 \cdot m^{-3} \cdot kg^{-1} \cdot s^2)^2}$$

$$= \frac{kg \cdot C^4}{kg^2 \cdot m^4 \cdot s^{-2} \cdot C^4 \cdot m^{-6} \cdot kg^{-2} \cdot s^4}$$

$$= kg \cdot m^2 \cdot s^{-2} = J$$

2) A

The acceleration on the plane is only the centripetal force

$\frac{mv^2}{r} = ma_c$

$a_c = 4.82 m/s^2$

since the plane is moving at constant speed

$F_{air} = F_{thrust}$

$F_{air} = 1000\ kN$

3) B

This question is simply asking us to calculate the perimeter of the circle that the space station goes through.

$6.371 \times 10^6 + 435 \times 10^3 = R_{new}$

$15.5 \cdot 2\pi R_{new} = \text{distance}$

$= 6.62496 \times 10^8$

4) C

$F = \frac{\Delta P}{\Delta t}$

case 1: $\xrightarrow{4m/h}$ $\xrightarrow{2km/h}$

case 2: $\xrightarrow{4km/s}$ $\xleftarrow{2km/h}$

under elastic collision ...

after collision:

case 1: $\xrightarrow{2km/h}$ $\xrightarrow{4km/h}$

case 2: $\xleftarrow{2km}$ $\xrightarrow{4km/h}$

$$F_1 = \frac{m \cdot \cancel{4} \cancel{+} m \cdot 2}{\Delta t} = \frac{2m}{\Delta t}$$

$$F_2 = \frac{-2m - 4m}{\Delta t} = \frac{-6m}{\Delta t}$$ 3 times bigger

5) A

for half of the time the weight measure would be ~~#~~ $(m+M)g$ and for the other half is $Mg$

since there are "many periods", the average would gradually approach $(m+M)g$

6) A

the change in angle only occurs when the acceleration is changing, therefore, the change in angle is 0

7) A

The formula for air resistence is $\frac{1}{2} C\rho \cdot A \cdot v^2$

Therefore, the force is proportional to $v^2$ so the answer is A

9) A

Electric field always points to potential "decrease"

$\xrightarrow{\vec{E}}$ ⊖ , therefore, A corresponds with the answer.

10) D

After C touches A, the charges on both spheres become $-\frac{1}{2}q$

when C with $-\frac{1}{2}q$ touches B, the charges on both spheres become $-\frac{3}{4}q$

$$\bar{F} = \frac{kq_1q_2}{r^2} = -\frac{kq^2}{r^2}$$

$$\bar{F}_{new} = \frac{3}{8}\frac{kq^2}{r^2} \qquad F_{new} = -\frac{3}{8}F$$

11) B

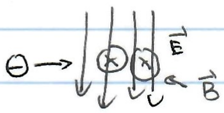
$$F_{D\,on\,B} = \sqrt{F_{C\,on\,B}^2 + F_{A\,on\,B}^2}$$

$$\frac{\mu_0 I_u}{2\sqrt{2}\pi r} \cdot I_2 \cdot l = \sqrt{\frac{\mu_0^2 I^2}{2\pi r^2} \cdot I_2^2 \cdot l^2}$$

$$\frac{\mu_0 I_u}{2\sqrt{2}\pi r} \cdot I_2 \cdot l = \frac{\mu_0 I}{\sqrt{2}\pi r} \cdot I_2 \cdot l$$

$$I_u = 2I$$

12) D




$$\vec{B}q\vec{v} = \vec{E}q$$

$$\vec{v} = \frac{\vec{E}}{\vec{B}}$$

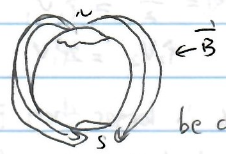
13) B

Proton is moving backward, and the acceleration on the proton is the same as the direction of the Electric field.

14) D


there are 2 gravitational forces acting on the particle, therefore, by the vector sum. $F_{electric} = \sqrt{2}mg$

15) C




If the coil ~~spins~~ swings in the plane of the coil, there will not be any change in magnetic flux, since the magnetic field remains the same at the same distance from the north pole, while case 2 swings and changes the distance, therefore, the answer is C.

16) D

From the equation:

$$E_K = \frac{3}{2} N k_B T$$

$$E_K = \frac{3}{2}(1)(1.38 \times 10^{-23})(25+273)$$

$$= 6.1686 \times 10^{-21}$$

17)

18) A

In this case, V increases as ~~P~~ T increases, so we look for the graph that presents similarly. Only "A" corresponds with the initial condition, that V is increasing while T is increasing

19) A

$$e_{new} = 1 - \frac{T_H - C}{T_C - C}$$ the change in denominator has a larger impact than the change in numerator, so the $\frac{T_H}{T_C} > \frac{T_H - C}{T_C - C}$

20) B

Before merging there are 2 bubbles

room temperature → $T_1$    $V_1$    $V_1$    =>    $T_1$   $V_2$    $P_2V_2 = n_2RT_1$

$P_1V_1 = nRT_1$    $P_1V_1 = nRT_1$

after stablizing

$n_2 = 2n$    $P_2V_2 = 2nRT_1$

$$nRT_1 = \frac{P_2V_2}{2} = P_1V_1$$

$$P_2V_2 = 2P_1V_1$$

$P_2V_2$ is larger than $P_1V_1$

Following the basic pattern of thermodynamics, if V is not restricted to be unchangable, then an increase on the Right hand side of the equation results in the increases in both P and V.

21) B

thermometer only reads the temperature of the mercury.

22) C

option A is not necessarily correct since it is possible that 2 explosions occur 1 second apart but more than $ct = x$ distance ~~away~~ between 2 explosions.

option B is not necessarily correct because ~~at~~ for some occasions, 2 explosions can be 1 second apart but the distance between them is not $ct$

option C is correct because both explosions can occur at the same time.

option d is incorrect, because Bob is moving with a constant $\vec{v}$, so the positions of 2 explosions would be different from $t=0$ to $t=t_1$ from Bob's perspective.

23)

24) B

Approaching case 1: $f_{new_1} = \left(\frac{c-V_m}{c+V_a}\right)f$ $\quad f = \frac{c}{\lambda}$ $\quad f_{new_1} = \frac{c-V_m}{\lambda_1}$

leaving case 2: $f_{new_2} = \left(\frac{c+V_m}{c-V_a}\right)f$ $\quad f = \frac{c}{\lambda}$ $\quad f_{new_2} = \frac{c+V_m}{\lambda_2}$

$\Downarrow$

case 1: $\frac{c-V_m}{\lambda_1} = f_{new_1} = \left(\frac{c-V_m}{c+V_a}\right)\frac{c}{\lambda}$

$\lambda_1 = \frac{c+V_a}{c} \cdot \lambda$

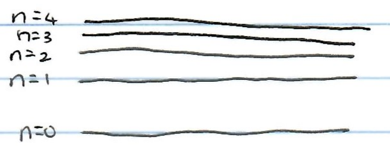
case 2: $\frac{c+V_m}{\lambda_2} = f_{new_2} = \left(\frac{c+V_m}{c-V_a}\right)\frac{c}{\lambda}$

$\lambda_2 = \frac{c-V_a}{c} \cdot \lambda$

$$\frac{\lambda_1}{\lambda_2} = \frac{c+V_a}{c-V_a}$$

25) B

The stages of electrons are like this:




The further the stage goes up, the lower the energy stored between each stage.

Therefore $hf_1$ from $n=2$ to $n=1$

is greater than (>) $hf_2$ from $n=3$ to $n=2$

which means $f_1 > f_2$ and $\lambda_1 < \lambda_2$