2020 厦大杯中学物理比赛
2020 XMUM Cup Physics Competition for Secondary School

Answers

Question	Acceptable Answers		Question	Acceptable Answers
Q1	16		Q13	42
Q2	8.3		Q14	0.25
Q3	0.26,0.27,0.28		Q15	16
Q4	16,17,18		Q16	4.5
Q5	15		Q18	30
Q6	0.53,0.54		Q19	5.3
Q7	3.0,3		Q20	0.89
Q8	3.3		Q21	1.7
Q9	9.1,9.2		Q22	6.9
Q10	1.5		Q23	9.4,9.5,9.6
Q11	1.5		Q24	0.46,0.47,0.48
Q12	2.5		Q25	0.88,0.89,0.90

Solution

Question 1.

An empty beaker is floating in water with one-third of its height submerged. The height and the diameter of the beaker are 10 cm and 4 cm, respectively. How many 5.0 grams beads can be placed in the beaker before it sinks? ***Keep 2 significant figures for your answer***. (Ans: 16)(Given density of water 1.0 gcm^{-3})

一个空的烧杯漂浮在水中，其高度的三分之一浸在水面下。 烧杯的高度和直径分别为 10 cm 和 4 cm。 在烧杯沉没之前，可以在烧杯中放入多少 5 g 的珠子？ ***答案取 2 位有效数字***。（已知水的密度为 1 gcm^{-3}）

Acceptable Answer : 16

Solution:

The mass of water to be excluded $M = \rho V$

The mass of beaker $m = \frac{1}{3}\rho V$

The mass to sink the beaker $M - m = \frac{2}{3}\rho V$

The number of beads to sink the beaker $\left(\frac{2}{3} \times 1 \times \pi \times 2^2 \times 10\right)\frac{1}{5} = 16.75$

Question 2.

The distance from the Earth to the Sun is 1.496×10^{11} m. When A solar flare occurs on the sun's surface, calculate how much time (in minutes) would it take for the electromagnetic radiation from the flare reach the Earth. Assume the Earth and the Sun are point masses, speed of light is 3×10^{8} ms^{-1}. ***Keep 2 significant figures for your answer***. (Ans: 8.3 minutes)

地球与太阳的距离为 $1.496x10^{11}$ m。当太阳耀斑发生在太阳表面时，估算耀斑产生的电磁辐射到达地球所需的时间（以分钟为单位）。假设地球与太阳可视为质点，光速为 3×10^{8} m / s。***答案取 2 位有效数字***。

Acceptable Answer： 8.3

Solution:

$t = 1.496x10^{11} / 3 \times 10^{8} = 500$ s = 8.3 minutes

Question 3

The Moon moves around the Earth in a nearly circular orbit with a radius of 384000 km and a period T of 27.3 days. Calculate the acceleration of the Moon towards the Earth in the unit of cms^{-2} . ***Keep 2 significant figures for your answer***. (Ans: 0.27)

月球以半径 384,000 公里，周期 T 为 27.3 天的近圆形轨道绕地球运动。 以 cms^{-2} 为单位计算月球相对地球的加速度大小。***答案取 2 位有效数字***。

Acceptable Answer : 0.26 or 0.27 or 0.28

Solution:

$$a = r\omega^2 = 3.84 \times 10^8 \times \left(\frac{2\pi}{27.3 \times 24 \times 3600}\right)^2 = 0.27\ cm/s^2$$

Question 4

When the temperature of a metal cube is raised from 0 °C to 100 °C, its volume increases by 0.5 %. To two significant figures, find the linear expansion coefficient of the metal in unit of 10^{-6} °C^{-1}. ***Keep 2 significant figures for your answer***. (Ans: 17)

当金属立方体的温度从 0°C 升高到 100°C 时，其体积将增加 0.5%。 保留两个有效数字，求金属的线膨胀系数以 10^{-6} 为单位。 ***答案取 2 位有效数字***。

Acceptable Answer: 1.6 or 1.7 or 1.8

Solution:

$$\frac{\Delta V}{V} = 3\alpha\Delta T$$

$$0.005 = 3\alpha 100$$

$$\alpha = 1.7 \times 10^{-5}$$

Question 5

A 45 kg ice skater moving at 10 ms^{-1} is picked up by her 75 kg partner, who is skating in the same direction at 18 ms^{-1}. They then move off together. What is the velocity of their centre of mass after the collision? (in unit of ms^{-1}) ***Keep 2 significant figures for your answer***. (Ans: 15 ms^{-1})

一 45 kg 的溜冰员正以 10 ms^{-1} 的速度运动，她 75kg 的伙伴以 18 ms^{-1} 的速度朝同一方向滑行，并与她结合在一起后继续前进。求碰撞后两人质心的速率 (以 ms^{-1} 为单位) 。 ***答案取 2 位有效数字***。

Acceptable Answer : 15

Solution:

(a) Taking $m_1 = 45$ kg and $m_2 = 75$ kg, the position of the centre of mass is

$$x_{\mathrm{CM}} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}.$$

The velocity of the centre of mass before collision is

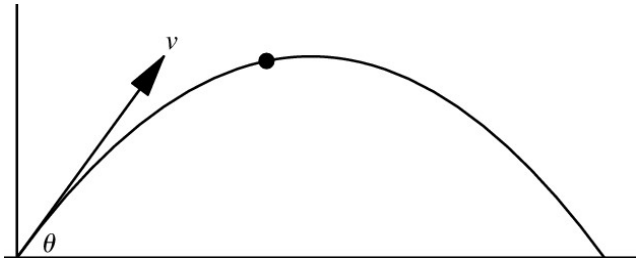
$$v_{\mathrm{cm}} = \frac{\mathrm{d}x_{\mathrm{CM}}}{\mathrm{d}t} = \frac{1}{m_1 + m_2}\left(m_1 \frac{\mathrm{d}x_1}{\mathrm{d}t} + m_2 \frac{\mathrm{d}x_2}{\mathrm{d}t}\right) = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$
$$= \frac{45(10) + 75(18)}{45 + 75} = \mathbf{15}\ \mathrm{m\,s^{-1}}.$$

(b) Since there are no external forces, the velocity of the centre of mass after collision is the same, $\mathbf{15}\ \mathrm{m\,s^{-1}}$.

Question 6

In the future, packages can be delivered all around the world by launching them in the air using railgun technology. A package would thus follow the trajectory of a projectile motion to reach its destination. Using the railgun, you plan to deliver a 70-kilogram package across a 1-kilometer-wide river within 11 s. Both the launching and receiving position are at the same horizontal. Determine the maximum launching angle (in radians) with the ground. Assume gravity acceleration g = 9.8 ms^{-2} and ignore the air drag. ***Keep 2 significant figures for your answer.*** (Ans: 0.54 rad)

在未来，人们可以使用轨道炮技术将包裹空运到世界各地。包裹将沿着抛物体运动的轨迹到达目的地。 现欲将一 70 公斤的包裹以此技术在 11 秒内跨过 1 公里宽的河流运送至目的地，发射位置与接收位置同在一水平面上。试求包裹相对于水平面的最大发射角度（以弧度为单位）。 假设重力加速度 g = 9.8 ms^{-2}，忽略空气阻力。 ***答案取 2 位有效数字***。



Acceptable Answer : 0.53 or 0.54

Solution:

0 = v sine (theta) – 9.8 t_{top} where t_{top} is the time taken to reach the maximum height of the projectile.

Since we can assume that the projectile motion is a symmetrical parabola, the time taken to reach the top equals the time taken to land. The reach the destination within 11 s, it must thus reach the top in 5.5 s. Thus

v sine (theta) = 53.9 m/s --- (1)

Similarly, for the horizontal motion, due to symmetry, the package must reach the halfway point when it is at maximum height. This should occur when the halfway point is 500 m, such that

x_{top} = v cosine (theta) t_{top}

v cosine (theta) = 90.9 m/s --- (2)

Divide equations (1) with (2), we get

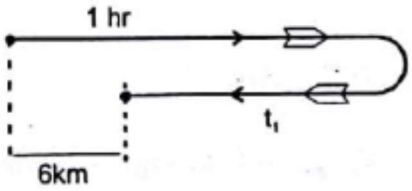
tangent (theta) = 0.592894, theta = 0.54 rad

Question 7

A motorboat and a raft are both going downstream at different constant velocities. The raft only relies on the river flow to move. The motorboat overcame the raft at a point A. 1 hour later, it turned back and travelled with the same speed after some time, passed the raft again at a distance 6.0 km from the point A. Find the flow speed (in kilometers per hour) assuming that the time for the boat to turn back is negligible and the speed of the boat does not change. ***Keep 2 significant figures for your answer***. (Ans: 3.0 kmh^{-1})

汽艇和木筏以不同的匀速度向下游行驶。 木筏只依靠河水移动。汽艇在 A 点超越木筏。1 小时后，汽艇回转，并以相同速率行驶一段时间后，又在距离 A 点 6. 0 公里处再次经过了木筏。求河水流动的速率（以公里/小时为单位）。***答案取 2 位有效数字***。

Solution:



Acceptable Answer: 3.0 or 3

Solution:

Let *"after some time"* equal to t, so that the motion of the raft with velocity u moving 6 km downstream is equal to

u x (1 + t) = 6

Let v be the additional velocity the motor boat has on top of the downstream flow velocity, such that

(u + v) x 1 – (v - u) x t = 6

v - vt + u x (1 + t) = 6

Thus, v – vt = 0, and t = 1 hour.

The flow velocity, u = 6/2 = 3 km/hour

Question 8

Two blocks of masses M_1 = 15.0 kg and M_2 = 3.0 kg are connected via a frictionless pulley and are on top of an incline of angle β = 60°, as shown in Fig. 1. Assuming all surfaces are frictionless, and the ropes are extendible, determine the magnitude of the acceleration of the blocks in unit of ms^{-2}. ***Keep 2 significant figures for your answer***. (Ans: 3.3 ms^{-2})

如图 1 所示，两个质量分别为 M_1 = 15.0 kg 和 M_2 = 3.0 kg 的木块以绳索跨过光滑的滑轮相连接，并放置于角度为β= 60°的斜面上，假设所有表面均无摩擦并且绳索可伸展。，求木块的加速度大小(以 ms^{-2} 为单位)。***答案取 2 位有效数字***。

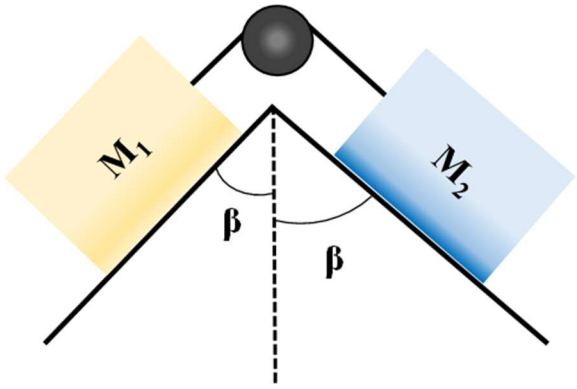


Figure 1

Acceptable Answer : 3.3 or 3.2

Solution: *The free-body diagram of M_1 and M_2 are*

$$M_1 a = M_1 g \cos\beta - T, \quad (1)$$
$$M_2 a = T - M_2 g \cos\beta, \quad (2)$$

Adding up the two equations,

$$(M_1 + M_2)a = M_1 g \cos\beta - M_2 g \cos\beta$$
$$a = \frac{(M_1 - M_2) g \cos\beta}{M_1 + M_2}.$$

Substituting in the values,

$$a = 3.27 \ \mathrm{m\,s^{-2}}$$

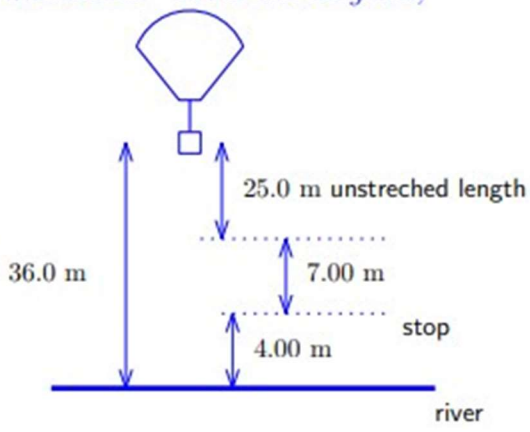
Question 9

In a bungee jumping attempt, a student jumps from a hot-air balloon with a specially designed elastic cord attached to their waist. The unstretched length of the cord is 25.0 m and the student weighs 700 N, and the balloon is 36.0 m above the surface of the river below. By treating the student as a point mass, calculate the required elastic constant k (in unit of Ncm^{-1}), if the student is to stop safely 4.0 m above the river. ***Keep 2 significant figures for your answer***. (Ans: 9.1 Ncm^{-1})

在蹦极跳中，一名学生从热气球上跳下来，腰部系有一条特别设计的弹性绳。绳索的未拉伸长度为 25.0 m，学生的体重为 700 N，气球位于河流表面上方 36.0 m。若将学生视为质点，求欲使学生在河面上方 4.0 m 处安全停下，所需绳索的弹性常数 k（以 Ncm^{-1} 为单位）。***答案取 2 位有效数字***。

Acceptable Answer : 9.1 or 9.2

Solution: *From the diagram,*



The elastic cord must extend by $x = 7.00$ m. *By the conservation of energy,*

$$mg(36 = \frac{1}{2}kx^2 + mg(4)$$

$$mg(32) = \frac{1}{2}kx^2$$

$$700(32) = \frac{49}{2}k$$

$$k = \mathbf{914}\ \mathrm{kg\,s^{-1}}.$$

Question 10

A solid metal sphere of radius 1.0 cm has a total charge 4.5 C. It is connected by a fine resistive wire to a distant, initially uncharged, metal sphere of radius 2.0 cm. Calculate the final charge on the metal sphere of 1.0 cm in unit of Coulomb. ***Keep 2 significant figures for your answer***. (Answer: 1.5)

半径为 1 cm, 总电荷为 4.5C 的固体金属球，通过细电阻丝连接到远处半径为 2cm，最初不带电的金属球上。 试以库伦 C 为单位，给出半径为 1 cm 的金属球上的最终电荷。***答案取 2 位有效数字***。

Acceptable Answer : 1.5

Solution:

$$V_1 = V_2$$

$$\frac{Q_{1f}}{r_1} = \frac{Q_{2f}}{r_2}$$

$$Q_{2f} = 2Q_{1f}$$

$$Q_{2f} + Q_{1f} = 4.5C$$

$$Q_{1f} = 1.5C$$

Question 11

Two blocks of masses *M* and 2*M* are connected by a spring as shown in figure. The heavier block is suspended from a string attached to the ceiling and the whole system remains at rest. The string breaks suddenly. Immediately after the string breaks, Find the instantaneous downward acceleration of the heavier block in terms of gravity g. ***Keep 2 significant figures for your answer*** (Ans: 1.5)

如图所示，两个质量分别为 M 和 2M 的物体通过弹簧连接后，以一根琴弦将其悬挂在天花板，并处于静止状态。某一时刻琴弦突然断裂，计算在琴弦断裂的瞬间，质量较大的物体的向下加速度为重力加速度 g 的多少倍？***答案取 2 位有效数字***。

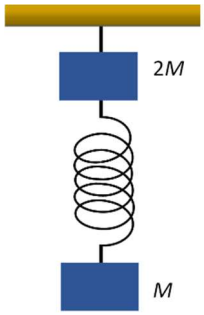


Figure 2

Acceptable Answer : 1.5

Solution:

$$T_1 - Mg = 0 - - - 1$$

$$T_2 - T_1 - 2Mg = 0 - - - 2$$

$$\therefore T_2 = 3Mg$$

At the moment the string breaks

$$3Mg = 2Ma$$

$$a = 1.5g$$

Question 12

Figure 3 shows a circuit with long chain of identical resistor cells. If R = 3.42 Ω, determine the value of Rx (in Ω) such that the total resistance between points A and B is independent of the number of cells. ***Keep 2 significant figures for your answer***. (Answer: 2.5 Ω)

图 3 显示了一个由相同的电阻单元链接组成的长链电路。 如果 R = 3.42 Ω，试求 Rx 的值（以Ω为单位），以使点 A 和点 B 之间的总电阻与单元数无关。 ***答案取 2 位有效数字***。

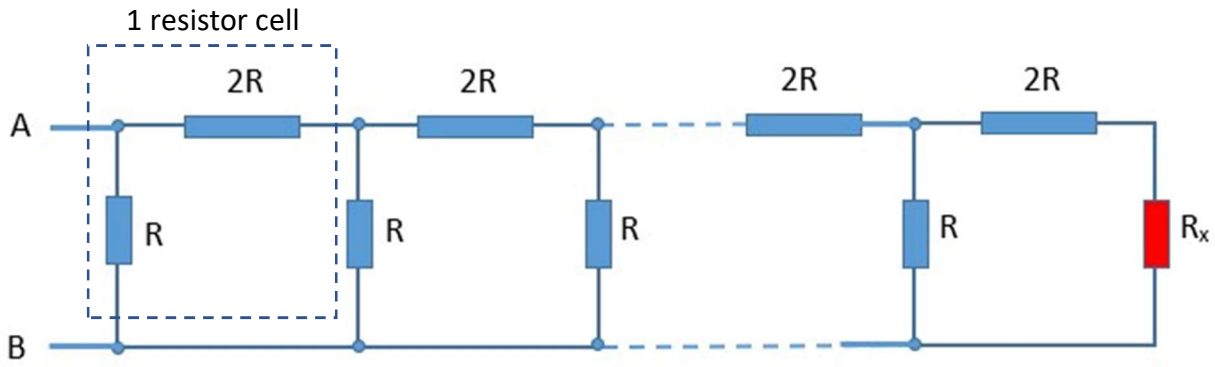
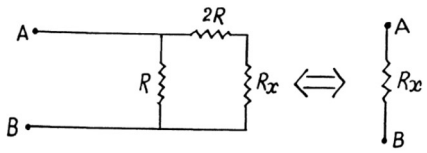


Figure 3

Acceptable Answer : 2.5

Solution:

Start combining the resistance from the chain end in series (2R + Rx) then in parallel (2R + Rx)//R. Self-similarity will happen when the combination yields the value of Rx, which can be used to combine with the next cell, ad-infinitum.



$$R_x = \frac{(R_x + 2R)\,R}{R_x + 2R + R}$$

$$R_x^2 + 2R\,R_x - 2\,R^2 = 0$$

$$R_x = R\left(\sqrt{3} - 1\right)$$

Rx = 0.732 x 3.42 ohm = 2.5 ohm

Question 13

Two bowling balls with a mass of 7.25 kg are positioned in a vertical cylinder such that they fit one above the other. The inner surface of the cylinder contacts with the Bowling ball without friction. The diameter of a bowling ball is 21.8 cm. Assume the bowling balls have identical charge Q, coulomb constant k = 9.0 x 10^9 N m^2 C^{-2}, and gravity acceleration g = 10 ms^{-2}. Determine the value of Q (in μC) such that the electrostatic repulsive force balances the distance between the nearest surface of the two balls at 25 cm. ***Keep 2 significant figures for your answer***. (Ans: 42 μC)

将质量为 7.25 kg 的两个保龄球放在一个垂直的圆柱体中，使其中球堆叠在另一球的正上方。圆柱体内壁与保龄球接触但无摩擦。保龄球的直径为 21.8 cm。假设保龄球具有相同的电荷 Q，库仑常数 k = 9.0 x 10^9 N m^2 C^{-2}，重力加速度 g = 10 ms^{-2}。求 Q 的数值(以 μC 为单位)，以使静电排斥力将两球最近的表面距离平衡在 25 cm。 ***答案取 2 位有效数字***。

Acceptable Answer : 42

Solution:

Electric force between two balls = kQ^2/r^2, where r is the distance of separation between the center of mass of both balls when one of the ball is lifted 25 cm. Thus, r = 46.8 cm. Electric force must balance the weight (gravity force) of the levitating ball, so that

9.0 x 10^9 $Q^2/(0.468)^2$ = 7.25 (10) → Q = 4.2 x 10^{-5} = 42 μC

Question 14

A charge q is placed on the origin of the x-axis, and a charge rq is placed on the x-axis at position x = 1.00 m, as shown in Fig. 2. r is a constant whose value is in the range 0 < r < 1. Find the value of r such that the electric field is zero at position x = $\frac{2}{3}$ m. ***Keep 2 significant figures for your answer***. (Ans: 0.25)

如图 2 所示，将电荷 q 放置在 x 轴的原点上，将电荷 rq 放置在 x 轴 x = 1.00 m 的位置上。其中 r 是一个常数，其值 在 0 <r <1 的范围内。求 r 的数值使得电场为零的位置在 x = $\frac{2}{3}$ m。***答案取 2 位有效数字***。

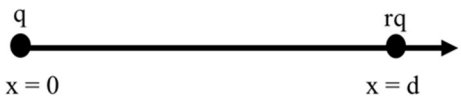


Figure 4

Acceptable Answer : 0.25

Solution: *On the x-axis, the electric field due to the q and rq respectively are*

$$\vec{E}_1 = \frac{q}{4\pi\epsilon_0 x^2}\hat{x}, \quad \vec{E}_2 = -\frac{rq}{4\pi\epsilon_0(d-x)^2}\hat{x}.$$

The total electric field is

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = \frac{q^2\hat{x}}{4\pi\epsilon_0}\left(\frac{1}{x^2} - \frac{r}{(d-x)^2}\right) = \frac{q^2\hat{x}}{4\pi\epsilon_0}\frac{(1-r)x^2 - 2dx + d^2}{x^2(d-x)^2}.$$

To have $\vec{E} = 0$, we require

$$(1-r)x^2 - 2dx + d^2 = 0.$$

Solving the quadratic equation for x, we find

$$x = \frac{d}{1-r}\left(1 \pm \sqrt{r}\right).$$

For $r = \frac{1}{4}$, the solution lower sign gives the solution lying in $0 < x < d$, which is

$$x = \frac{2}{3}d = 0.667 \text{ m}.$$

Question 15

A cup with height H_{cup} and diameter 14.64 cm partially filled with water to a height of 7.80 cm. A student looks downward just over the left rim of the cup at an angle of θ = 40.47° with the water's surface. At this angle, the refraction of light at the water's surface just barely allows her to see the bottom-right corner of the cup. Assume the refractive index of water is 1.33 and refractive index of air is 1. Determine the height of the cup in unit of cm. ***Keep 2 significant figures for your answer***. (Ans: 16 cm)

一个高度为 H_{cup}，直径是 14.64 cm 的杯子, 装有 7.80 cm 高的水。 一个学生从杯子的左边缘上方向下看，且与水表面呈 40.47 度角时，水面折射的光线恰能使她看到杯子的右下角。 假设水的折射率为 1.33，空气的折射率为 1。求杯子的高度 H_{cup}（以 cm 为单位）。 ***答案取 2 位有效数字***。

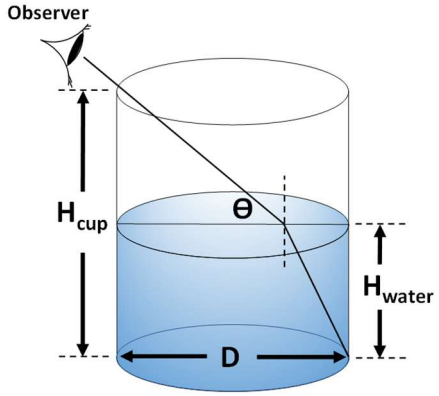


Figure 5

Acceptable Answer : 15 or16

Solution:

Use Snell's law to determine angle of refraction in the water:

1 sine (49.53) = 1.33 sine (alpha), alpha = 34.89

Water height = 7.80 cm (given), use information to find the location of ray entry

tangent (alpha) = x/7.8, x = 5.44 cm, thus D-x = 9.2 cm

Find the height of cup unfilled by water, H

tangent (40.47) = H/9.2, H = 7.85 cm

Thus, Cup height = 7.8+7.85 = 15.65 cm = 16 cm

Question 16

In an automobile engine, a mixture of air and vaporised petrol is compressed in the sealed cylinders before being ignited. The initial temperature and pressure of the mixture before compression are 27 °C and 1.00 atm, respectively. After the mixture is compressed to $\frac{1}{9}$ of the initial volume, the pressure increases to 21.7 atm. Considering the mixture as an ideal gas, determine the final temperature in unit of 10^2 °C after compression. ***Keep 2 significant figure for your answer***. (Ans: 4.5)

在某个汽车引擎中，空气和汽化汽油形成的混合物在未被点燃前会于密闭的气缸中被压缩。混合气体的初始温度和气压分别为 27 °C 和 1.00 atm，当混合气体被压缩至原来体积的 $\frac{1}{9}$ 时，压力为 21.7 atm。若视混合气体为理想气体，求混合气体被压缩后的最终温度。以 10^2°C 为单位。***答案取 2 位有效数字***。

Acceptable Answer : 4.5

Solution: *By the ideal gas law, the quantities before compression satisfy*

$$P_1V_1 = nRT_1. \tag{13}$$

After compression, the state variables satisfy

$$P_2V_2 = nRT_2. \tag{14}$$

Dividing the two,

$$\frac{P_1V_1}{P_2V_2} = \frac{T_1}{T_2} \quad \rightarrow \quad T_2 = T_1\frac{P_2}{P_1}\frac{V_2}{V_1} \tag{15}$$

Given the initial uncompressed quantities $P_1 = 1.00$ atm, $T_1 = 27°\text{C} = 300$ K, *and the final pressure is* $P_2 = 21.7$ atm. *Note that the volumes are not given, but we do know the final volume is* $1/9$ *of the initial. Therefore* $\frac{V_2}{V_1} = \frac{1}{9}$. *Substituting these numbers into (15), we find*

$$T_2 = 723\text{ K} = 450°\text{C}. \tag{16}$$

Question 18

A cylinder with a piston contains a monoatomic ideal gas at a volume V_0. Energy is transferred by heat into the system and is allowed to expand to a final volume $8V_0$. Throughout the expansion, the relationship between the pressure and volume is given by $P = \frac{4}{3}\kappa V^{1/3}$, where κ is a constant. If κ = 2.00 N m^{-3} and V_0 = 1.00 m^3, find the work done by the gas in unit of J. ***Keep 2 significant figures for your answer***.(Ans: 30 J)

一具有活塞的气缸中含有体积为 V0 的单原子理想气体。当能量通过热量传递到系统中时，气体体积膨胀到 8V0。 在整个膨胀过程中，压力与体积之间的关系保持为 P = 4 3κ V1/3，其中κ= 2.00 N m-3 且 V0 = 1.00 m3，求气体对外界做的功(以 J 为单位)。***答案取 2 位有效数字***。

Acceptable Answer : 30

Solution: *Given* $P = \frac{4}{3}\kappa V^{1/3}$. *The initial and final volumes are* $V_1 = V_0$ *and* $V_2 = 8V_0$. *The work done is*

$$W = \int_{V_1}^{V_2} P\,dV = \int_{V_0}^{8V_0} \frac{4}{3}\kappa V^{1/3}\,dV = \frac{4}{3}\kappa\left[\frac{3}{4}V^{4/3}\right]_{V_0}^{8V_0}$$
$$= \kappa\left((8V_0)^{4/3} - V_0^{4/3}\right) = 30.0\ \text{J}.$$

Question 19

Dart gun A can eject a dart 2.3 times faster than dart gun B. If both guns are fired vertically upwards, what is the ratio of maximum heights achieved from a dart from A, compared to the dart from B? ***Keep 2 significant figures for your answer***.(Ans 5.3)

飞镖枪 A 的飞镖发射速度是飞镖枪 B 的 2.3 倍。如果两把枪垂直向上发射，那么从 A 射出的飞镖与从 B 射出的飞镖的最大高度之比是多少？***答案取 2 位有效数字***。

Acceptable Answer : 5.3

Solution: *Let v_A and v_B be the speed ejected from A and B, respectively. Given*

$$v_A = 2.3v_B.$$

By conservation of energy of dart A,

$$\frac{1}{2}mv_A^2 = mgh_A$$
$$m(2.3v_B)^2 = 2mgh_A$$
$$5.29v_B^2 = 2gh_A. \quad (3)$$

By conservation of energy of dart B,

$$\frac{1}{2}mv_B^2 = mgh_B$$
$$v_B^2 = 2gh_B. \quad (4)$$

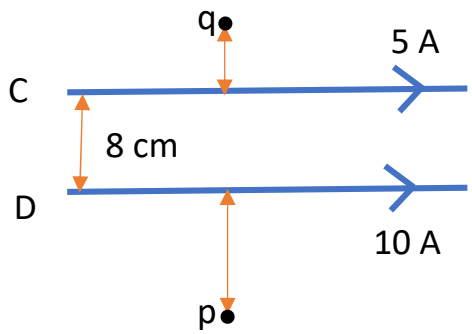
Dividing Eq. (3) with (4),

$$\frac{5.29\cancel{v_B^2}}{\cancel{v_B^2}} = \frac{h_A}{h_B} \quad \rightarrow \quad \frac{h_A}{h_B} = \mathbf{5.29}.$$

Question 20

Two parallel, long wires C and D carry current 5 A and 10 A, respectively flowing in same direction. The distance between C and D is 8 cm. Let B_p and B_q denote the magnetic strength at point p and q, respectively which are in the same plane of the two wires. Find the ratio B_p/B_q if point q is at distance 5 cm from C and point p is at distance 10 from D. ***Keep 2 significant figures for your answer***.(Ans: 0.89)

C, D 为两条平行长导线，分别带有 5 A 和 10 A 相同方向的电流。两导线的距离为 8cm。B_p 和 B_q 分别表示 p 和 q 点上的磁场强度，p 点和 q 点与两导线共平面。若 q 点与 C 的距离为 5cm, p 点与 D 的距离为 10 cm，求比值 B_p/B_q。***答案取 2 位有效数字***。



Acceptable Answer : 0.89

Solution:

$$B_p = \frac{10\mu_0}{2\pi 10} + \frac{5\mu_0}{2\pi 13} = \frac{\mu_0}{2\pi} 1.384$$

$$B_q = \frac{5\mu_0}{2\pi 5} + \frac{10\mu_0}{2\pi 18} = \frac{\mu_0}{2\pi} 1.56$$

$$\frac{B_p}{B_q} = 0.89$$

Question 21

Photoelectric emission happens when a beam of light strikes a metal surface. The stopping potential for the ejected electrons is 5.0 V, and the work function of the metal is 2.2 eV. Determine the frequency of the incident light in unit of 10^{15} Hz. (Given Planck's constant 6.626×10^{-34} m^2 kg s^{-1} and electron charge is 1.6×10^{-19} C .) ***Keep 2 significant figures for your answer***. (Ans:1.7)

当光束撞击金属表面时会发生光电效应。 光电子的遏止电压为 5.0 V，金属的功函为 2.2 eV。 以 10^{15} Hz 为单位, 求入射光的频率。(已知普朗克常数为 6.626×10^{-34} m^2 kg s^{-1}, 电子电荷量为 1.6×10^{-19} C) ***答案取 2 位有效数字***。

Acceptable Answer : 1.7

Solution:

$$Ek = hf - W$$

$$5eV = hf - 2.2eV$$

$$hf = 7.2\ eV$$

$$f = 7.1 \times 1.6 \times 10^{-19} \frac{1}{6.626} \times 10^{34}$$

$$f = 1.7 \times 10^{15}\ Hz$$

Question 22

The following figure represents the energy levels of a certain atom. If a gas of such atoms is irradiated by a beam of white light (visible light ranges from 380 nm to 700 nm), what wavelength(in unit 10^{-7}m) of absorption lines are expected in the spectrum, when the experiment is viewed along the beam axis? Given Planck's constant 6.626×10^{-34} m^2 kg s^{-1}. ***Keep 2 significant figure for your answer***. (Ans: 6.9 x 10^{-7}m)

下图表示某个原子的能级。 如果用白色光束（可见光波长在 380 nm 到 700nm）照射由这种原子组成的气体，那么沿光束轴观察实验的光谱时，其吸收谱线的波长是多少 10^{-7}m？已知普朗克常数为 6.626×10^{-34} m^2 kg s^{-1}。***答案取 2 位有效数字***。

Figure 6

Acceptable Answer : 6.9

Solution:

Only the transition 3 to 2 is in visible light.

$$\frac{hc}{\lambda} = 1.8eV$$

$$\lambda = \frac{hc}{1.8eV} = 6.9 \times 10^{-7}m$$

问题 23 至 25 为虚拟实验题, 参赛者须通过以下链接进入虚拟实验室。在虚拟实验室中, 按照题目的要求获取相关数据以求得正确答案。最后再回到此页, 将答案填入对应的空格中.

Questions 23 to 25 are virtual experimental questions. Participants must enter the virtual laboratory through the following link. In the virtual laboratory, obtain the relevant data according to the requirements of the question and use the data to calculate the correct answer. Finally, return to this page and fill the answers in the corresponding box.

Question 23(Reference Ans: 9.5)

Determine the spring constant in unit of Nm^{-1}. ***Keep 2 significant figures for your answer***.

In this virtual lab, you can

1. change the mass of the block by dragging the slider.

2. install or uninstall the block to the spring by clicking on the button ' Install the mass'.

3. turn off or turn on the ultrasonic sensor which can display the position of the block in the graph.

4. click 'Reset' button to bring everything back to default.

求弹簧系数, ***答案以*** Nm^{-1} *为单位,* ***取 2 位有效数字***。

在此虚拟实验室中, 你可以

1.拖曳滑块来改变木块的质量。

2.点击按钮'Install the mass'将木块安装到弹簧上。

3.关闭或打开超声波感应器, 将木块的位置显示在图表上。

4.点击按钮'Reset'恢复初始设定。

Question 24(Reference Ans: 0.47)

Determine the density of the string in unit of gm^{-1}. ***Keep 2 significant figures for your answer***.

In this virtual lab, you can

1. change the mass hanging over the pulley by dragging the slider.

2. increase or decrease the frequency of vibrator by clicking on the button '+ 1 Hz' or '-1 Hz'.

3. read the amplitude of the string vibration from the graph.

4. click 'Reset' button to clear the graph.

求弦的线密度，***答案以 gm^{-1} 为单位，取 2 位有效数字***。

在此虚拟实验室中， 你可以

1.拖曳滑块来改变悬挂在滑轮上的质量。

2.点击按钮 button '+ 1 Hz' or '-1 Hz'来增加或减少振动频率。

3.从图表中读取弦振动的振幅。

4.点击按钮'Reset'清除图表。

Question 25(Reference Ans: 0.89)

Determine the specific heat capacity of unknown metal ball in unit of $Jg^{-1}{}^{o}C^{-1}$. ***Keep 2 significant figures for your answer***.

In this virtual lab, you can

1. measure the mass of an object by dragging it to the electronic scale.

2. heat on object by dragging it to the heater.

3. open the cover by clicking the button 'Open cover'.

4. fill in the water to the beaker by putting the beaker under the water tap and click the button 'Open water tap'

5. click 'Reset' button to bring everything back to default.

6. Given specific heat capacities of beaker, cover and thermometer are 0.50 $Jg^{-1}\ {}^{o}C^{-1}$. Specific of water is 4.18 $Jg^{-1}\ {}^{o}C^{-1}$.

求未知金属的比热容量，***答案以*** $\boldsymbol{Jg^{-1}{}^{\circ}C^{-1}}$ *为单位，****取 2 位有效数字***。

在此虚拟实验室中， 你可以

1.拖曳物件到电子秤上以测量质量。

2.拖曳物件到加热器上以进行加热。

3.点击按钮'Open cover'以打开烧杯盖子。

4.将烧杯放置在水龙头下点击按钮'Open water tap'， 以加入水。

5.点击按钮'Reset'恢复初始设定。

6.已知烧杯， 盖子和温度计的比热容量都为 500 $Jg^{-1}\ {}^{o}C^{-1}$。

水的比热容量为 4.18 $Jg^{-1}\ {}^{o}C^{-1}$。

********** End of Paper **********

****试卷结束****