**2016 NJC SH2 H1 Physics Prelim Paper Suggested Solutions**

**Paper 1**

| 1 | C | 11 | A | 21 | B |
|---|---|----|---|----|---|
| 2 | D | 12 | B | 22 | B |
| 3 | B | 13 | A | 23 | B |
| 4 | C | 14 | C | 24 | B |
| 5 | D | 15 | C | 25 | C |
| 6 | D | 16 | A | 26 | B |
| 7 | C | 17 | A | 27 | C |
| 8 | A | 18 | A | 28 | B |
| 9 | A | 19 | B | 29 | D |
| 10 | C | 20 | A | 30 | B |

**Paper2**

**Section A**

1(a)(i)　Now consider a body of mass $m$ at rest brought to velocity $v$ over a distance $s$ by a constant force $F$.
The final velocity $v$ is given by $v^2 = u^2 + 2as$,

where $a$ is constant acceleration given by $a = \dfrac{F}{m}$.

We have $v^2 = u^2 + 2\dfrac{F}{m}s$.

Rearranging, $\quad \rightarrow F\,s = \dfrac{1}{2}mv^2 - \dfrac{1}{2}mu^2$

The change in Kinetic Energy of an object equals the net work done on the object.
Since the body starts from rest ($u = 0$), its final kinetic energy of body = work done on body by F $= E_k = \dfrac{1}{2}mv^2$.

1(a)(ii)　Since the speed is constant, the change in KE is zero. Hence, by COE, the chemical energy is all used to do work against air resistance and thus no such transformation taking place.

1(b)(i)　P = W / t
36.6 x $10^3$ = W / 300
W = **1.1x$10^7$ J**

1(b)(ii)　Not worthwhile, since the KE =3.46 x $10^5$ J even when it is moving at 31 m $s^{-1}$ and thus will be even lower when it slows down. Hence, since the KE will be so much lower than the WD against the resistive force, a large part of the energy would still be provided by the fuel of the car.

2(a)    Consider a collision that occurs when A collides with B in a straight line.
By Newton's second law the change in momentum for A, $\Delta p_A = F_{BA} * \Delta t$, where $F_{BA}$ is the force B exerts on A and $\Delta t$ is the duration the force is exerted while the change in momentum for B, $\Delta p_B = F_{AB} * \Delta t$, where $F_{AB}$ is the force A exerts on B.
By Newton's third law, $F_{BA} = - F_{AB}$ since they are an action-reaction pair.
Hence, $\Delta p_A = - \Delta p_B$.
This implies $p_{AF} - p_{AI} = - (p_{BF} - p_{BI})$, where $p_{AF}$ is the final momentum of A, $p_{AI}$ is the initial momentum of A, $p_{BF}$ is the final momentum of B and $p_{BI}$ is the initial momentum of B.
Rearranging, $p_{AI} + p_{BI} = p_{AF} + p_{BF}$. This implies the total initial momentum is the same as the total final momentum if no external force acts on this system.

2(b)(i)    The total initial momentum of the system is zero. Hence the total final momentum is zero, implying that the final momentum of magnet A = - (final momentum of magnet B). If the mass of both magnets are the same, then the final velocity of magnet A = - (final velocity of magnet B).

2(b)(ii)    Work was done on both magnets since an external force was applied to oppose the repulsive magnetic force between the two magnets. This was stored as potential energy between the two magnets resulting in an increase in kinetic energy when the external force was removed.

3(a) (i)    Electric current is rate of flow of charged particles.
The resistance of a body is defined as the ratio of potential difference across it to the current passing through it.

(ii)    Q = It = 25000 (40 x 10⁻⁶) = **1.00 C**

(iii)    V = IR = 5 x10⁻³(1000) = **5.00 V**

3(b) (i)    R = $\rho \dfrac{L}{A} = 5\dfrac{1.6}{\pi(0.05)^2} = 1018 = $ **1020 $\Omega$**

(ii)    Yes. When the circuit is closed, there will be a *potential difference drop due the internal resistance* (key point), thus the pd across his hand will be lower than 14 kV.

(iv)    Current through the mechanic, $I = \dfrac{V}{R} = \dfrac{14k}{(2000k + 1018)} = 7.00mA$ [1]
Since current through mechanic, $I$ = 7.00 mA is higher than maximum safe current which is 5.0 mA, it will kill the mechanic. [1]

4(a)    Principle of Superposition states that when two or more waves meet at a point, the resultant displacement at that point is equal to the vector sum of the displacements due to the individual waves at that point.

4(b)(i)    Wave travel down the tube and gets reflected by the water.
The incident and the reflected waves, both having the same amplitude, frequency(or wavelength) and speed travelling in opposite directions superpose to form standing wave.
**OR**
The incident sound wave travels along the tube and is reflected by the water.
The superposition of the incident and reflected wave of same amplitude, speed and wavelength(or frequency) but travelling in opposite directions creates a standing wave in the pipe.

4(b)(ii) The length of the air column in tube will limit the type of stationary wave which can be formed within the air column as there is the boundary condition that it has to be a node formed at the closed end of the air column and a antinode at the open end of the air column. In general, the length of the air column L needs to be equal to $\lambda(2n+1)/4$, where $\lambda$ is the wavelength of the incident wave and n is an integer. If this condition is met, the loudness of the sound will be maximum, otherwise the sound will be of lower amplitude.

4(b)(iii)
$$\frac{\lambda}{4} = L_1 + c \quad \text{-------------(1)} \qquad c \text{ is the end correction}$$

$$\frac{3\lambda}{4} = L_2 + c \quad \text{-------------(2)}$$

$$(2) - (1) \Rightarrow \quad \frac{1}{2}\lambda = L_2 - L_1 = 32.4 \text{ cm}$$

$$\Rightarrow \quad \lambda = 64.8 \text{ cm}$$
$$v = f\lambda = 512 \times 0.648 = 332 \text{ m s}^{-1}$$

4(b)(iv) $\frac{1}{4}\lambda = L_1 + c = 15.7 + c \Rightarrow c = \frac{1}{4} \times 64.8 - 15.7 = 0.50$ cm

Therefore, antinode is 0.50 cm above the top of the tube OR antinode is 16.2 cm above water surface.
There is a presence of end correction. The region of lowest pressure is not at the mouth of the tube but is actually a distance away from end of tube.

5 (a) The waves from the loudspeakers must have about the <u>same amplitude</u>. [1]

5(b)(i) wavelength of sound $\lambda = v / f = 340/ 680 = 0.5$ m
Fringe separation $x = \lambda D/ a = (0.5)(20) / 3 = 3.33$ m
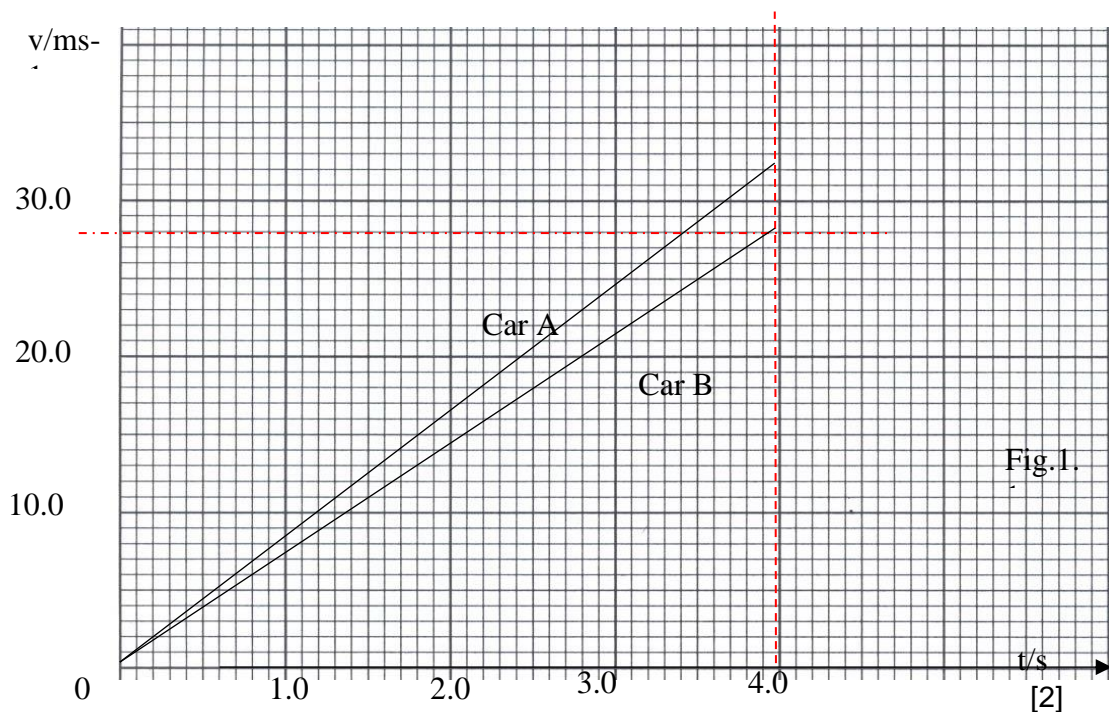Hence for the 3rd minimum, distance = 2.5 x 3.33 = **8.33 m**

5(b)(ii) When the two loud speakers are connected, there is destructive interference of the sound waves at point Z. When $L_2$ is disconnected, there is no longer any interference, hence there is no destructive interference at point Z and the intensity of sound will be higher than before.
Though there is an increase in intensity of sound at point Z, the total energy of the system is still equal to the output energy of speaker $L_2$, hence it does not conflict with the law of conservation of energy.
[When $L_2$ is connected, the total energy of the system was equal to the sum of the output energy of speaker $L_1$ and $L_2$. The energy has been redistributed due to interference as there will be points of constructive and destructive interference.]

5(c) The signal received by the microphone will not be a minimum at places which was previously of maximum intensity and vise-versa.

## Section B

6 (a)(i)1.



y-axis labeled: v/ms⁻¹ with values 10.0, 20.0, 30.0
x-axis labeled: t/s with values 1.0, 2.0, 3.0, 4.0
Curves labeled: Car A, Car B
Fig.1.

[2]

6(a)(i)2.   Distance travelled by car A = ½ x 4.0 x 32.0 = 64.0 m
Distance travelled by car B = ½ x 4.0 X 27.8 = 55.6 m
Distance between the cars = 64.0 - 55.6 = **8.4 m**

6(a)(ii)1.   Acceleration of car A, $a_A$ = 27.8/3.5 = 7.94 ms⁻²
Acceleration of car B, $a_B$ = 27.8/4.0 = 6.95 ms⁻²
Effective acceleration of car A = $a'_A$ = ($a_A$ x 0.8) – gsin 30°
= 7.94 x 0.8 -9.81 (0.5)
=1.447 =**1.45 m s⁻²**
Effective acceleration of car B = $a'_B$ = $a_B$ – gsin 30°
= 6.95 - 9.81 (0.5) = 2.045 = **2.05 m s⁻²**

6(a)(ii)2.

V/ms⁻¹



Fig.1.2
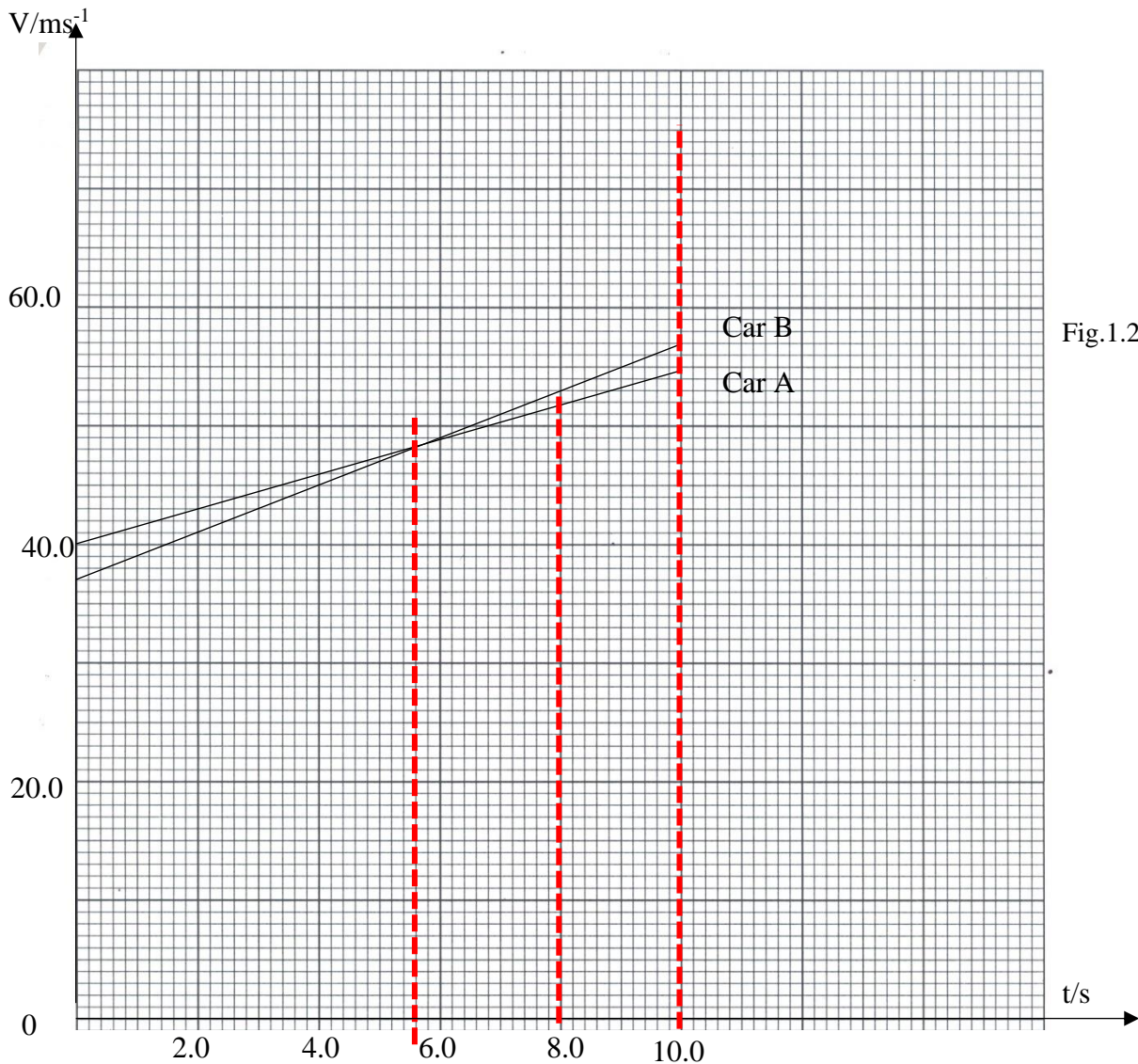
$V_A = 40 + 1.45 (10) = 54.5$ ms⁻¹
$V_B = 37 + 2.05 (10) = 57.5$ ms⁻¹

6(a)(ii)3.     The area under the velocity-time graph will give the displacement of the car.
From the graph, at t = 8.0 s, the area under the graph of Car A is bigger than the area under the graph by Car B. From t = 0 to t = 5.4 s, Car A covered a larger distance. From t = 5.8 s to t = 8.0 s, Car B covered a larger distance. Comparing the 2 regions, area under the graph by car A is still more than shaded area B. Hence Car A has covered more distance than Car B at t = 8.0 s.

Or

The 2 cars' velocities are equal at t = 5.8 s. Car A is ahead of Car B. Hence for the displacement to be the same, Car B can only be together with Car A at t = 11.6 s. Hence at t = 8.0 s, car B will still be behind Car A.

6(b)(i)1.     $F_{Spring} = 6g \sin 40° + 4g \sin 40° = 10(9.81) \sin 40° = 63.057$ N = **63.1 N**

6(b)(i)2.     $F_{Spring} = kx$
63.057 = 400 x
X = 0.1576 m = **0.158 m**

6(b)(i)3.   $F_{net}$ on block A = $4g \sin 40°$
            $6a = 4g \sin 40°$
            $a = 4/6 (9.81) \sin 40° = $ **4.20 m s$^{-2}$**

6(c)(ii)1.  With only Block A,
            $6g \sin 40° = 400X_A$
            $X_A = 0.094586$ m = 0.0946 m
            By conservation of energy,
            Loss in Gravitational Potential energy of the system = gain in Elastic potential Energy
            $4g (0.2 \sin 40°) + 10 g x \sin 40° = ½ (400) (x^2 – 0.094586^2)$
            Hence x = 0.401 m or x = -0.0853 m (Not applicable)
            The new compression of the spring is 0.401 m

6c(ii)2.    Due to the additional compression, there will be a resultant force on Blocks A and B after the instance of being momentarily stationary. Hence both blocks will move up the slope. Once, they lose contact with the spring, they will decelerate and by conservation of energy will reach a maximum height which is lower than 0.2 m up the slope. The two blocks will slide down the slope again and compress the spring. This will continue till the two blocks settle down on the spring with a compression of 0.158 m.
            [Note: There is work done on the spring hence the system will not be simple harmonic.]

7(a) A magnetic field is a region of space in which a magnetic pole, a current-carrying conductor or a moving charged particle located in it will experience a force.

7(b) By Fleming's Left Hand Rule, the direction of the force on coil XY by magnet is downwards. By Newtons's $3^{rd}$ Law, the force acting on the magnet by coil is upwards. The reading on balance is measured by the normal contact force acting on magnet. Once the current is switched on, the normal contact force acting on magnet is reduced, i.e weight – magnetic force on magnet. Therefore, reading on scale decreases.

7(c)(i) $F = NBIL$
$F = 120 \times 0.45 \times 15 \times 10^{-3} \times 2x\,\pi \times 25 \times 10^{-3} = \textbf{0.127 N}$

7(c)(ii) A fluctuating electric current flows through the coil.
Since the coil is perpendicularly to a magnetic field, it experiences a magnetic force and the magnitude of force is proportional to the current.
As the coil is attached to the speaker cone, the cone will oscillate with an amplitude that is proportional to the amplitude of current in coil.

7(d)



There is no force at the vertical sides of coil Y.
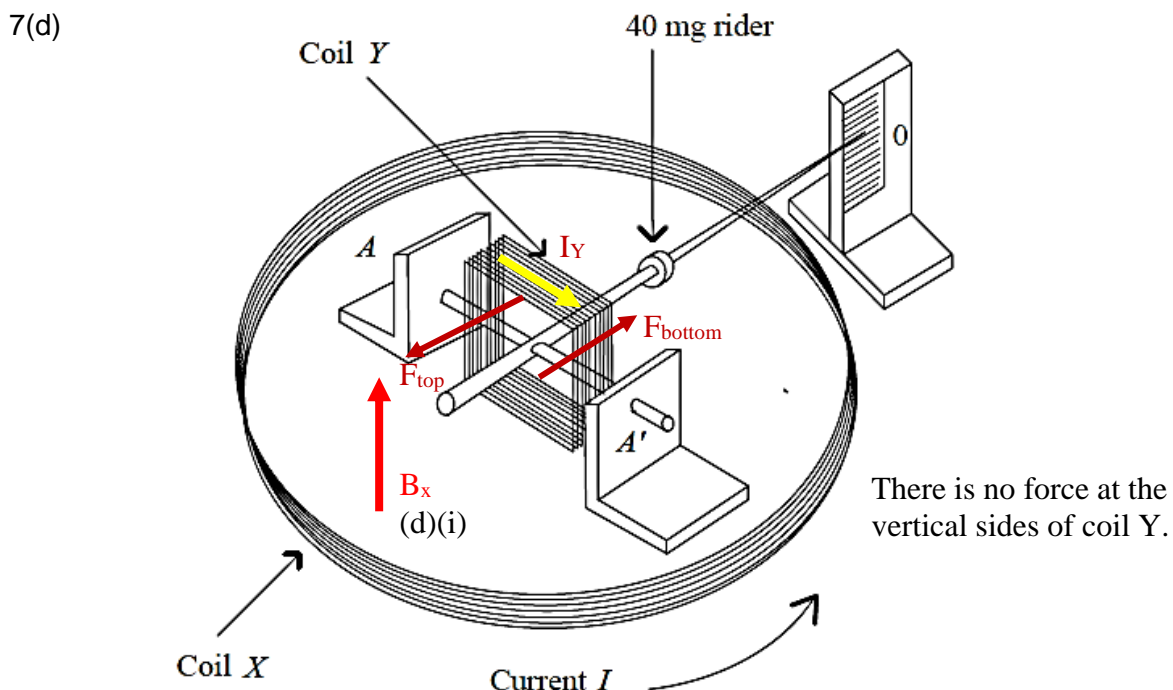
7(e)(i) When the switch is closed, a closed circuit is formed. Hence, current flows through the external components as well as the internal resistance of the battery. There will be a potential difference across the internal resistance, which results in the voltmeter measuring a value (terminal potential difference) which is lower than the e.m.f of the battery.

7(e)(ii) Effective resistance of the load R = 14 + [1/60 +1/40]$^{-1}$ = 38 Ω
Current = V/ R = 11.4 / 38 = **0.30 A**

7(e)(iii) E = Ir + IR
12.0 = 0.30 r + 11.4 ➔ r = **2.0 Ω**

7(e)(iv) With bulb B removed, the effective resistance of the circuit decreases. The potential difference across bulb A decreases and bulb A becomes dimmer. By potential divider rule, the potential difference across bulb C increases and bulb C becomes brighter.

8(a)(i)   The excited Lithium gas will emit photons as they de-excite. There should be ($^6C_2 =$ )15 possible lines. As Lithium de-excite from -2.5 eV to -5.7eV, the photon emitted has energy 3.2 eV which matches the energy difference of the Sodium from -3.8 eV to 0.6 eV. When Lithium de-excite from -1.4 eV to -2.5 eV, the photon emitted has energy of 1.1 eV which matches the energy difference of Sodium from -1.7 eV to -0.6 eV. These two photons will be absorbed by the Sodium atom, hence only 13 lines will be detected.

8(a)(ii)  When electrons of 3.7 eV collides with the cooled sodium gas, it can excite the sodium gas from energy level 1 (-3.8 eV) to energy level 4 (-0.18eV). When these excited atoms de-excite, photons will be emitted. There should be 6 different photon energies observed, these will be of different frequencies from the 13 from the hot lithium gas.

8(b)      When violet light is incident on the barium metal, photoelectric effect takes place, the electrons near the surface of barium absorbed the photon and was able to overcome the work function of barium metal to escape as photoelectrons. Hence barium gains a positive charge due to the loss of electrons.

8(c) □    As a quantum of energy, if the photon has energy that is more than the work function of the metal it will be absorbed by the electron. Since each electron can only absorb one photon and the energy of a photon cannot be shared by more than one electron, there is no accumulation of energy through absorption of multiple photons. Hence, there is no time delay in the emission of photoelectrons.

8(d)      As there are only specific values for the kinetic energy, it suggest that the photons which are incident are of only specific values. Since photons from the atom will have energy equal to the difference energy between the atom's energy levels and hence there are only specific allowed energy levels. The energy levels in the hydrogen atom are discrete.

8(e)      The electron at the metal surface require the least amount of energy to be emitted, hence it has maximum kinetic energy.
          Electrons that are not directly below the surface require energy to bring it to surface, so less kinetic energy.
          Hence, there is a range of kinetic energy up to a maximum value for the electrons.

8(f)(i)   In a crystalline solid, the regularly arranged atoms (or the atomic spacing between the atoms is constant) acts like a diffraction grating.

8(f)(ii)  The electrons behave as a wave since electron diffraction take place. Electrons are accelerated and gained kinetic energy.
          Only electrons of suitable kinetic energies ($E_k = \frac{p^2}{2m_e}$) have momentum and the de Broglie wavelength, i.e. p = $\frac{h}{\lambda}$ associated with this momentum is of the same order of magnitude as the atomic spacing, i.e $10^{-10}$ m.

8(f)(iii) For a observable diffraction pattern, wavelength $\lambda = 0.142 \times 10^{-9}$ m
          By De Broglie's relation, p = $\frac{h}{\lambda}$ = 6.63 x $10^{-34}$ / 0.142 x $10^{-9}$ = 4.669 x $10^{-24}$ Nm

          Kinetic energy of the electron, E = $p^2$ / 2m = (4.669 x $10^{-24}$)$^2$/ 2(9.11x$10^{-31}$) =1.20 x $10^{17}$ J