Section B: Atomic World

B1. Which of these conclusions could NOT be deduced from Rutherford's scattering experiment?

1. Alpha particles are helium nuclei. → right-angled track in cloud chamber
2. There are discrete energy levels in an atom. → emission/absorption spectrum
3. The positive charge in an atom is confined to a very small region.

A. (1) only  
B. (3) only  
C. (1) and (2) only  
D. (2) and (3) only

Answer: C

B2. The equivalent wavelength of a photon of energy 10 eV is

A. 213 nm  
B. 124 nm  
C. 25.6 nm  
D. 19.7 nm

Answer: B

B3. The ionization potential of a hydrogen atom is 13.6 V. How much energy is required to excite an electron from the ground state to the first excited state in a hydrogen atom?

A. 10.2 eV  
B. 6.8 eV  
C. 3.4 eV  
D. 1.9 eV

Answer: A

B4. The energy levels of a certain atom are as shown. Which of these may undergo an inelastic collision with the atom?

1. an electron with kinetic energy 3E ✓
2. a photon with energy 2E ✓
3. a photon with energy 3E → no absorption of photon

A. (2) only  
B. (3) only  
C. (1) and (2) only  
D. (1), (2) and (3)

Answer: C
B5. In an experiment on the photoelectric effect, a beam of monochromatic light is directed onto a metal plate to liberate electrons. The velocity of the fastest photoelectrons emitted is

A. directly proportional to the frequency of the incident light.
B. directly proportional to the intensity of the incident light.
C. independent of the nature of metal.
D. independent of the intensity of the incident light.

Answer: D

B6. The work function \( W \) of five metals are tabulated below.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Caesium</th>
<th>Barium</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Beryllium</th>
</tr>
</thead>
<tbody>
<tr>
<td>W / ( 10^{-19} ) J</td>
<td>3.4</td>
<td>4.0</td>
<td>4.6</td>
<td>5.9</td>
<td>8.0</td>
</tr>
</tbody>
</table>

When monochromatic light of wavelength 400 nm is incident on each of the metals, how many of them would exhibit photoelectric emission?

A. 1
B. 2
C. 3
D. 4

Answer: C

B7. Which of the following statements is/are correct?

(1) Photoelectric effect is an evidence that light possesses particle nature.
(2) Electron diffraction suggests that electrons can behave like waves.
(3) The line spectrum of atomic hydrogen suggests that the atom has discrete energy levels.

A. (1) and (2) only
B. (2) and (3) only
C. (1) and (3) only
D. (1), (2) and (3)

Answer: D

B8. Graphite is a conductor because of the 'delocalization' of electrons. Where are these delocalized electrons?

A. formed on the surface of graphite.
B. formed within the carbon layers of graphite.
C. formed homogeneously within graphite.
D. formed in a 'sea' of positive ions.

Answer: B
Section B: Atomic World

B1. C
B2. B
B3. A
B4. C
B5. D
B6. C
B7. D
B8. B

B9. (a) The de Broglie wavelength of the electron is given by
\[ \lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}} \]
\[ = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.11 \times 10^{-31} \times 1.60 \times 10^{-19} \times V}} \]
\[ \approx \frac{1.23}{\sqrt{V}} \]

(b) (i) The wavelength of the electrons is
\[ \lambda = \frac{1.23}{\sqrt{50 \times 10^3}} = 0.0055 \text{ nm} \]

(ii) The electron beam is focused onto the sample by the magnetic field of the condenser lens. The transmitted beam through the sample is then projected by the (magnetic) objective and projector lenses onto an imaging device. Due to the different degree of transmission of electrons at different regions of the sample, the details of the sample can be displayed by the imaging device according to the information carried by the transmitted beam.

(iii) The resolving power can be increased by increasing the accelerating voltage \( V \) so that the wavelength \( \lambda \) of the electrons can be further decreased so as to minimize the effects of diffraction (or using Rayleigh criterion).

(c) Nanoparticles (e.g. aluminium oxide) used in cosmetic products to improve cleaning effects on our skin. A thin layer of nano paint containing nanoparticles possesses anti-bacterial and detoxicating abilities (e.g. used to prevent SARS).

(Accept other reasonable answers.) These nanoparticles are so small that they may enter our body through the skin. Their long-term effects on human body are not known, and may pose threat to our health.

(Accept other reasonable answers.)
Section C: Energy and Use of Energy

1. The Coefficient of Performance (COP) of a heat pump is
   A. the ratio of energy absorbed from the cold reservoir to the energy rejected to the hot reservoir.
   B. the heat energy rejected to the hot reservoir per unit work input.
   C. the ratio between the total energy input to the useful work done.
   D. the ratio between the extra work input to the total energy input.

   Answer: B

2. In the figure, a light source is a perpendicular distance \( h \) above a horizontal surface. The amount of illuminance (unit: lux) of a point on the surface at a distance \( R \) from the source is directly proportional to

   \[
   E = \frac{F \cos \theta}{4 \pi R^2}
   \]

   \[
   = \frac{F \cos \theta}{4 \pi} \left( \frac{1}{\cos \theta} \right)^2
   \]

   A. \( \cos^2 \theta / R^2 \)
   B. \( \cos^2 \theta / h^2 \)
   C. \( \cos^2 \theta / h^2 \)
   D. \( \cos \theta / R^2 \)

   Answer: C

3. If each fission of uranium-235 liberates 200 MeV of energy, how much uranium-235 must undergo fission per second to generate a power of 1000 MW?

   A. \( 2.0 \times 10^{-24} \) kg
   B. \( 2.2 \times 10^{-10} \) kg
   C. \( 5.2 \times 10^{-8} \) kg
   D. \( 1.2 \times 10^{-5} \) kg

   Answer: D

4. Which of these is NOT an advantage of Battery Electric Vehicle?

   A. zero emission
   B. low energy cost per kilometre covered
   C. long mileage range
   D. energy security by diversifying energy sources

   Answer: C
C5. Which of these actions reduces the heat gained in the summer by buildings in Hong Kong?

A. Increase the OTTV values of the building envelope X
B. Apply solar films on windows to reduce solar heat gain ✓
C. Minimise internal heat gain from indoor activities
D. Improve the air-tightness of the building envelope

Answer: B

C6. The solar constant is 1367 W m\(^{-2}\) (power per unit area from the Sun reaching the outer atmosphere) and the Earth-Sun distance is 1.50 \(\times\) \(10^{11}\) m (i.e. 1 AU), estimate the total radiation power of the Sun.

A. \(3.9 \times 10^{26}\) W
B. \(3.2 \times 10^{23}\) W
C. \(2.3 \times 10^{25}\) W
D. \(7.7 \times 10^{24}\) W

Answer: A

C7. In estimating the maximum power available from a wind turbine, what is assumed to true?

1. The density of air is constant.
2. The direction of wind relative to the orientation of the turbine is unchanged.
3. The area swept by the turbine is constant.

A. (1) and (2) only
B. (2) and (3) only
C. (1) and (3) only
D. (1), (2) and (3)

Answer: D

C8. A fuel cell cannot be classified as a Renewable Energy Source because

A. it is a secondary energy source.
B. its supply is limited.
C. it is from fossil sources.
D. the time scale for regeneration is too long.

Answer: A
Section C: Energy and Use of Energy

C1. B
C2. C
C3. D
C4. C
C5. B
C6. A
C7. D
C8. A

C9. (a) (i) The induction cooker's coil produces a high frequency/alternating magnetic field. The field penetrates the metal of ferrous cooking vessels and induces eddy currents to circulate in the metal for heat generation.

(ii) A considerable amount of energy is lost to the surroundings with a gas cooker as the temperature difference between the heating source and the environment is very high.

(iii) \[ E = mc\Delta T \]
\[ = (1 \text{ kg})(4200 \text{ J kg}^{-1}\text{C}^{-1})(100^\circ\text{C} - 25^\circ\text{C}) \]
\[ = 3.15 \times 10^5 \text{ J} \]

1M for correct equation for either cooking device

For the gas cooker,
\[ $0.25 \times \frac{3.15 \times 10^5 \text{ J}}{0.4} \times \frac{1}{1 \times 10^6 \text{ J}} \]
\[ = $0.197 \]

1A

For the induction cooker,
\[ $0.90 \times \frac{3.15 \times 10^5 \text{ J}}{0.75} \times \frac{1}{1000 \times 60 \times 60 \text{ J}} \]
\[ = $0.105 \]

(b) - CFLs and LEDs are more energy-efficient than incandescent light bulbs
- to reduce the emission of green-house gases from power plants
- to save fossil fuels, which are non-renewable
(ANY TWO, 1M for one correct advantage, 1.5M for two correct advantages)
- high initial capital for replacement of incandescent light bulbs by CFLs and LEDs
- improper disposal of CFLs can cause pollution due to the mercury inside them
- improper disposal of CFLs and LEDs poses the problem of electronic waste
(ANY TWO, 1M for one correct disadvantage, 1.5M for two correct disadvantages)

(Accept other reasonable answers)