Atomic Spectra Chemistry Questions with Solutions

Q-1: Atomic spectra is also known as
a) continuous spectra
b) line spectra
c) Spectra of absorption
d) The emission spectrum

Answer: b) line spectra
Explanation: Line spectra are obtained as a result of absorption and subsequent emission of energy by the electrons in the individual atoms of the element. Hence, the line spectrum is also called atomic spectrum.

Q-2: The atomic spectrum of Li^{2+} should be similar to that of
a) He^+
b) Na
c) He
d) H

Answer: a) and d)
Explanation: The atomic spectrums of mono electronic species are identical. A mono electronic species is a specie that contains only one electron.

He^+ and H contain only one electron. Hence their atomic spectrum is similar to mono electronic specie Li^{2+}.

Q-3: Calculate the radius ratio for 2nd orbit of He^+ ion and 3rd orbit of Be^{+++} ion.
Answer: The formula for radius is given by:

$$r_n = \frac{n^2 a_o}{z}$$

For He^+ ion, z=2, n=2(2nd orbit)

$$r_2 = \frac{2^2 a_o}{2} = 2a_o$$

For Be^{+++} ion, z=4, n= 3 (3rd orbit)

$$r_3 = \frac{3^2 a_o}{4} = \frac{9}{4} a_o$$

The radius ratio for 2nd orbit of He^+ ion and 3rd orbit of Be^{+++} ion comes out to be 8/9.

Q-4: The energy of an electron in a hydrogenic atom with nuclear charge Z varies as
a) Z
b) Z^2
c) 1/Z
d) $1/Z^2$

Answer: b) Z^2
Explanation: The expression for the energy calculation of an electron in a hydrogenic atom with nuclear charge Z and orbit number, n is given by:

$$E = \frac{-13.6Z^2}{n^2}$$

As a result, we can clearly see that it is proportional to Z^2.

Q-5: The potassium salts are placed in a Bunsen flame to obtain the line spectrum, the colour of the light emitted is
a) yellow
b) violet
c) green
d) white

Answer: b) violet
Explanation: The colour of the light emitted depends upon the nature of the substance. For example, sodium and its salts emit yellow light while potassium or its salts give out violet light.

Q-6: Name the gas that is used in the discharge tube to obtain the hydrogen absorption spectrum?
Answer: H_2 gas
Explanation: When H_2 gas is introduced into the discharge tube, a series of lines such as lyman, balmer, paschen, bracket, and pfund that are located in different regions are obtained.

Q-7: A α- line of Balmer series corresponds to
a) shortest wavelength with n_2=2
b) longest wavelength with n_2=2
c) longest wavelength with n_2=3
d) shortest wavelength with n_2=3

Answer: c) longest wavelength with n_2=3
Explanation: α- line of Balmer series is the first line of Balmer series.
For the Balmer series, $n_1 = 2$ and for the first line, $n_2 = n_1+1 = 2+1 = 3$

Q-8: Distinguish between the emission and absorption spectra.

Answer:

Emission Spectra	**Absorption spectra**
1) Emission spectrum is obtained when the radiation from the source is directly analysed in the spectroscope.	1) It is obtained when the white light is first passed through the substance and the transmitted light is analysed in the spectroscope.
2) It consists of bright coloured lines separated by dark spaces	2) It consists of dark lines.
3) It can be continuous or discontinuous.	3) It is always discontinuous.

Q-9: Calculate the wavelength of a photon emitted when an electron in H-atom makes a transition from n=2 to n=1.

Answer: According to Rydberg formula,

$$\frac{1}{\lambda} = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})z^2$$

Here, n_1= 1 and n_2=2 and R is the rydberg constant. Z is the atomic number of H-atom
Z=1 , R= 109677 cm^{-1}

Substituting in the formula, we get

$$\frac{1}{\lambda} = 109677(\frac{1}{1^2} - \frac{1}{2^2}) = \frac{3}{4} \times 109677$$

Thus, λ= 2.27 × 10^{-6} cm

Q-10: If an electron makes transition from the 7th excited state to 2nd state in a H-atom sample, find the maximum number of spectral lines observed.

Answer: The maximum number of spectral lines(N) can be calculated using the below formula:

$$N = \frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$$

Here, n_2 = 8(for 7th excited state) and n_1= 2. Substituting in the formula, we get

$$N = \frac{(8 - 2)(8 - 2 + 1)}{2}$$

N= 21

Q-11: The wavelength of lyman series lies in the
a) Visible region

b) Radio Waves region
c) Ultraviolet region
d) Infrared region

Answer: c) Ultraviolet region

Q-12: What is the name of the equipment used to analyse sunlight by splitting it into its various colours?
a) monochromator
b) spitter
c) spectrometer
d) spectrograph

Answer: c) and d)
Explanation: A spectrograph, also known as a spectroscope or spectrometer, divides light from a single material into its component colours in the same way that a prism divides white light into a rainbow. It captures this spectrum, allowing scientists to analyse the light and learn about the properties of the material interacting with it.

Q-13: A line at 3802 cm^{-1} is obtained in the infrared region of the atomic spectrum of hydrogen. Determine the energy of this photon.

Answer: Given, $\bar{\nu} = 3802\ cm^{-1}$
λ = (1/3802) cm
We know that, Energy, E= hν= hc/λ
Where h is the planck's constant and c is the speed of light,
h= 6.63×10^{-34}Js , c= 3×10^{8}m/s = 3×10^{10}cm/s

$$E = \frac{6.626 \times 10^{-34}\ J\ s \times 3 \times 10^{10}\ cms^{-1}}{3802\ cm} = 7.56 \times 10^{-20} J$$

Q-14: Which of the following is an example of line absorption spectrum?
a) Mercury vapour lamp
b) Sunlight Spectrum
c) Spectrum of oil flame
d) Solar spectrum

Answer: b) Sunlight Spectrum is an example of line absorption spectrum

Q-15: The correct order of Bohr radius is
a) $r_1>r_2>r_3>r_4$

b) $r_1<r_2<r_3<r_4$
c) $r_1=r_2=r_3=r_4$
d) $r_1<r_2>r_3<r_4$

Answer: b) $r_1<r_2<r_3<r_4$

Explanation: Bohr radius is represented by r_n where n is the orbit number. It is given by the formula:

$$r_n = \frac{n^2 a_o}{z}$$

As a result, as the value of n increases, so does the bohr radius.
Therefore the correct order is $r_1<r_2<r_3<r_4$

Practise Questions on Atomic Spectra

Q-1: Which theory was able to explain the line spectra of hydrogen?
a) Dalton's Atomic theory
b) Bohr's theory
c) Rutherford's model
d) Thomson's Atomic model

Answer: b) Bohr's theory
Explanation: The most remarkable achievement of Bohr's theory is that it provides a satisfactory explanation for the hydrogen line spectrum.

According to it, when an atom is subjected to high temperature or electric discharge, it may jump from the ground state to some higher energy level(excited state).

Because an electron's lifetime in the excited state is limited, it may return to a lower energy or even the ground state in one or more jumps, emitting a photon of light with a specific wavelength and frequency. As a result, a spectrum line is observed.

Q-2: Which electronic level allows the hydrogen atom to absorb but not emit photons?
a) 3s
b) 2p
c) 2s
d) 1s
Answer: d) 1s

Q-3: Calculate wavelength for the 2nd line of the Balmer series of He^+ ion.

Answer: According to the Rydberg formula,

$$\frac{1}{\lambda} = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})z^2$$

For the balmer series, n_1= 2 and for the second line, n_2=4

For He^+ ion, z=2 (Atomic number of Helium)

R= 109677 cm^{-1}

$$\frac{1}{\lambda} = 109677(\frac{1}{2^2} - \frac{1}{4^2})2^2$$

Thus, λ= 1.21 × 10^{-5} cm

Q-4: The principal quantum number of an atom is related to the

a) size of the orbital

b) orientation of the orbital in space

c) spin angular momentum

d) orbital angular momentum

Answer: a) size of the orbital

Q-5: Calculate the frequency of light emitted when an electron drops from the higher to the lower state if the energy difference between the two electronic states is 214.68 kJ/mol. (Planck's constant,h= 39.79× 10^{-14} kJs/mol)

Answer:

ΔE= hν

214.68 kJ/mol = 39.79× 10^{-14} kJs/mol × ν

ν = 5.395 × 10^{14} s^{-1}