1) Diagram I shows a glass tube containing undisturbed air molecules. Diagram II shows the same glass tube when a wave passes through it.

Which type of wave produced the disturbance shown in diagram II?
A) torsional  B) transverse  C) longitudinal  D) elliptical

2) An astronomer on Earth studying light coming from a star notes that the observed light frequencies are lower than the actual emitted frequencies. The astronomer concludes that the distance between the star and Earth is
A) not changing  B) decreasing  C) increasing

3) The amplitude of a sound wave is to its loudness as the amplitude of a light wave is to its
A) brightness  B) speed  C) color  D) frequency

4) Which wave phenomenon is represented in the diagram below?
A) refraction  B) reflection  C) diffraction  D) interference

5) The amplitude of the wave shown below is represented by the distance between points

A) A and B  B) E and D  C) A and D  D) A and C
6) As the period of a wave decreases, the wave's frequency
   A) decreases    B) remains the same    C) increases

Questions 7 through 10 refer to the following:

The diagram below represents the wave pattern produced by a vibrating source moving linearly in a shallow tank of water. The pattern is viewed from above and the lines represent wave crests.

![Wave Pattern Diagram]

7) The source is moving toward point
   A) A    B) B    C) C    D) D

8) The wave pattern is an illustration of
   A) dispersion    B) diffraction    C) the Doppler effect    D) interference

9) Compared to the frequency of the waves observed at point D, the frequency of the waves observed at point B is
   A) higher    B) the same    C) lower

10) The velocity of the source is increased. The wavelength of the waves observed at point D will
    A) remain the same    B) increase    C) decrease

11) Two wave sources operating in phase in the same medium produce the circular wave patterns shown in the diagram below. The solid lines represent wave crests and the dashed lines represent wave troughs.

![Wave Pattern Diagram]

Which point is at a position of maximum destructive interference?
   A) A    B) B    C) C    D) D
12) Red light passing through a double slit is producing a stationary interference pattern on a screen as shown in the diagram.

![Diagram of double slit experiment]

The interference pattern is produced because the light passing through the two slits is
A) refracted  B) diffracted  C) polarized  D) dispersed

13) A car radio is tuned to the frequency being emitted from two transmitting towers. As the car moves at constant speed past the towers, as shown in the diagram below, the sound from the radio repeatedly fades in and out.

![Diagram of radio towers and car]

This phenomenon can best be explained by
A) reflection  B) refraction  C) interference  D) resonance

14) A sound wave can not be
A) diffracted  B) polarized  C) refracted  D) reflected

15) An interference pattern is produced on a screen by a green monochromatic light beam that has passed through a single narrow slit. Which diagram best represents this pattern?

KEY: □ Black □ Green
A) □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □
17) The diagram below represents red light incident upon a double-slit barrier, producing an interference pattern on a screen. The wavelength of the red light is \(6.6 \times 10^{-7}\) meter, the distance \((d)\) between the slits is \(2.0 \times 10^{-3}\) meter, and \(X\) is \(3.3 \times 10^{-4}\) meter.

Which diagram best describes the pattern observed on the screen?

KEY: [ ] Black  [ ] Red

A)  

B)  

C)  

D)  

18) The diagram below shows a wave phenomenon. The pattern of waves shown behind the barrier is the result of

A) diffraction  
B) refraction  
C) interference  
D) reflection

19) A characteristic common to sound waves and light waves is that they

A) are transverse  
B) travel in a vacuum  
C) transfer energy  
D) are longitudinal
20) The diagram below shows a beam of light entering and leaving a "black box.”

The box most likely contains a
A) double slit  B) converging lens  C) polarizer  D) prism

21) A ray of monochromatic light $AB$ in air strikes a piece of glass at an incident angle $\theta$ as shown in the diagram below.

Which of the following diagrams below best illustrates the ray’s interaction with the glass?

A)  

B)  

C)  

D)
22) The diagram below shows radar waves being emitted from a stationary police car and reflected by a moving car back to the police car.

The difference in apparent frequency between the incident and reflected waves is an example of

A) constructive interference  C) the Doppler effect
B) total internal reflection  D) refraction

23) In the diagram below, two speakers are connected to a sound generator. The speakers produce a sound pattern of constant frequency such that a listener will hear the sound very well at A and C, but not as well at point B.

Which wave phenomenon is illustrated by this experiment?

A) interference  B) polarization  C) reflection  D) refraction

24) A periodic wave with a frequency of 10 hertz would have a period of

A) 100 s  B) 0.1 s  C) 10 s  D) 1 s

25) Which is an example of a longitudinal wave?

A) sound wave  B) x-ray  C) water wave  D) gamma ray

26) Which property of light is illustrated by the diagram below?

A) dispersion  B) reflection  C) refraction  D) diffraction
27) As shown in the diagram below, a beam of light can pass through the length of a curved glass fiber.

![Diagram of light passing through curved glass fiber](image)

This phenomenon is possible due to the effect of
A) dispersion  B) polarization  C) diffraction  D) internal reflection

28) In which diagram is angle \( \theta \) a critical angle?

![Diagrams of angles](image)

29) How many nodes are represented in the standing wave diagram below?

![Standing wave diagram](image)

A) 2  B) 3  C) 4  D) 6

30) Which diagram best illustrates the diffraction of waves?

![Diagrams of diffraction](image)

A)  B)  C)  D)

31) Which diagram best illustrates wave refraction?

![Diagrams of refraction](image)

A)  B)  C)  D)

32) The diagram below represents the path of periodic waves passing from medium \( A \) into medium \( B \).

![Diagram of wave path](image)

As the waves enter medium \( B \), their speed
A) remains the same  B) increases  C) decreases

33) In which type of wave is the disturbance parallel to the direction of wave travel?

A) transverse  B) longitudinal  C) torsional  D) circular
34) Two pulses are traveling along a string toward each other as represented in the diagram below.

Which phenomenon will occur as the pulses meet?
A) reflection  B) refraction  C) interference  D) diffraction

35) A periodic wave travels through a rope, as shown in the diagram below.

As the wave travels, what is transferred between points A and B?
A) both mass and energy  B) mass, only  C) neither mass nor energy  D) energy, only
1) The alkaline earth metals are in Group 
A) 1 B) 2 C) 11 D) 12

2) On the Periodic Table, an element classified as a semimetal (metalloid) can be found in 
A) Period 2, Group 14 B) Period 3, Group 16 C) Period 4, Group 15 D) Period 6, Group 15

3) Compared to the covalent atomic radius of a sodium atom, the covalent atomic radius of a magnesium atom is smaller. The smaller radius is primarily a result of the magnesium atom having 
A) more principal energy levels B) fewer principal energy levels C) a larger nuclear charge D) a smaller nuclear charge

4) What is the total number of occupied sublevels in an atom of chlorine in the ground state? 
A) 5 B) 9 C) 1 D) 3

5) Which of the following sublevels contains the greatest number of orbitals? 
A) s B) p C) d D) f

6) The highest ionization energies in any period are found in Group 
A) 2 B) 17 C) 18 D) 1

7) Proceeding from left to right in Period 2 of the Periodic Table, the covalent radius of the elements generally
A) decreases B) increases C) remains the same

8) Which group of elements occur only as compounds in nature because they are extremely reactive? 
A) 16 B) 1 C) 11 D) 18

9) What is the total number of sublevels in the second principal energy level? 
A) 2 B) 3 C) 4 D) 1

10) The electron dot symbol \( \cdot\cdot\cdot \cdot \cdot \cdot \cdot \) represents an ion of atom X. Atom X could be an atom of 
A) I B) H C) K D) S

11) Which element in Group 15 has the greatest metallic character? 
A) Sb B) N C) P D) Bi

12) More than two thirds of the elements of the Periodic Table are classified as 
A) nonmetals B) metalloids C) metals D) noble gases

13) The chemical properties of elements are periodic functions of their 
A) mass numbers B) atomic numbers C) oxidation states D) ionic charges

14) The elements with atomic number 10 has an electron configuration that is the same as 
A) Cl B) Cr C) Na\(^+\) D) Na

15) Which properties are characteristic of nonmetals? 
A) high thermal conductivity and low electrical conductivity 
B) low thermal conductivity and low electrical conductivity 
C) low thermal conductivity and high electrical conductivity 
D) high thermal conductivity and high electrical conductivity

16) Which atom may form a negative ion with the electron configuration \( 1s^2? \) 
A) Be B) Li C) H D) He
17) Which principal energy level of an atom contains an electron with the lowest energy?
   A) $n = 3$  B) $n = 4$  C) $n = 2$  D) $n = 1$

18) Which particle has the largest radius?
   A) Cu  B) Se$^{2-}$  C) Se  D) Cu$^{2+}$

19) Which element in Period 4 of the Periodic Table exhibits the most nonmetallic properties?
   A) Ga  B) Br  C) Cr  D) Ca

20) An atom of which of the following elements has the greatest ability to attract electrons?
   A) nitrogen  B) silicon  C) sulfur  D) bromine

21) What is the maximum number of electrons that can be contained in the $n = 4$ principal energy level?
   A) 50  B) 8  C) 32  D) 18

22) Which pair of Group 15 elements are nonmetals?
   A) arsenic and antimony  B) nitrogen and phosphorus  C) nitrogen and arsenic  D) phosphorus and bismuth

23) Compared to a Be$^{2+}$ ion, a Be$^0$ atom has
   A) more protons  B) more electrons  C) fewer electrons  D) fewer protons

24) According to the Radii of Atoms chemistry reference table, which of the following elements has the smallest covalent radius?
   A) cobalt  B) nickel  C) calcium  D) potassium

25) Which element within any given period of the Periodic Table would always have the lowest first ionization energy?
   A) a halogen  B) an alkali metal  C) an alkaline earth metal  D) a noble gas

26) Elements whose two outermost sublevels may be involved in a chemical reaction are called
   A) alkali metals  B) noble gases  C) transition metals  D) halogens

27) Which of the following particles has the smallest radius?
   A) K$^+$  B) Na$^+$  C) K$^0$  D) Na$^0$

28) Which element will form an ion whose ionic radius is larger than its atomic radius?
   A) K  B) Li  C) F  D) Mg

29) When a calcium atom loses its valence electrons, the ion formed has an electron configuration which is the same as an atom of
   A) Ar  B) Se  C) K  D) Cl

30) Which ion has the electron configuration of a noble gas?
   A) Ca$^{2+}$  B) Cu$^{2+}$  C) Hg$^{2+}$  D) Fe$^{2+}$

31) As the elements Li to F in Period 2 of the Periodic Table are considered in succession, how do the relative electronegativity and the covalent radius of each successive element compare?
   A) The relative electronegativity decreases and the covalent radius decreases.
   B) The relative electronegativity decreases and the covalent radius increases.
   C) The relative electronegativity increases and the covalent radius increases.
   D) The relative electronegativity increases and the covalent radius decreases.

32) Which element is an active nonmetal?
   A) oxygen  B) neon  C) chromium  D) zinc

33) As an electron moves from its ground state to an excited state, the potential energy of the atom
   A) remains the same  B) decreases  C) increases

34) In the modern Periodic Table, the elements are arranged according to
   A) oxidation number  B) mass number  C) atomic number  D) atomic mass

35) Which term refers to the region of an atom where an electron is most likely to be found?
   A) spectrum  B) quantum  C) orbit  D) orbital