

Final Exam

Name: _____

Closed-book, closed-notes. The use of a calculator and a periodic table is recommended. 100 points total.

1. Which of the following is the correct symbol for a species with five protons, six neutrons, and four electrons?

- (a) ${}^6\text{B}^+$
(b) ${}^{11}\text{B}^+$
(c) ${}^{11}\text{C}^+$
(d) ${}^{11}\text{Na}^+$

Answer _____

2. The "Wien displacement law" relates the wavelength at which a hot body emits its maximum intensity of EM radiation to the temperature in kelvin according to

$$\lambda_{\text{max}} = 2.897 \times 10^6 \text{ nm/T}$$

What is the approximate value of λ_{max} for the radiation emitted by the Earth, if its average surface temperature is 18°C?

- (a) 160944 nm
(b) 9955 nm
(c) 160.9 nm
(d) 99.55 nm

Answer _____

3. The density of water at 20°C is 0.99823 g cm⁻³. A student carried out three measurements of mass and volume and obtained the following values – Trial 1: 0.999 g cm⁻³, Trial 2: 1.014 g cm⁻³, Trial 3: 1.037 g cm⁻³. The measurements are

- (a) Precise but not accurate.
(b) Accurate but not precise
(c) Both precise and accurate.
(d) Neither precise nor accurate.

Answer _____

4. The transition ${}^{58}\text{Fe} \rightarrow {}^{59}\text{Fe}$ can be described as an example of

- (a) Alpha decay
(b) Electron capture
(c) Beta decay
(d) Neutron capture

Answer _____

5. The average atomic mass of Zn is 65.39 amu. Given the data below, what is the average abundance of ${}^{66}\text{Zn}$?

Isotope	mass (amu)	Abundance(%)
${}^{64}\text{Zn}$	63.9291	48.89
${}^{66}\text{Zn}$	65.9260	?
${}^{67}\text{Zn}$	66.9271	4.11
${}^{68}\text{Zn}$	67.9249	18.56
${}^{70}\text{Zn}$	69.9253	0.62

- (a) 27.81%
(b) 0.2781%
(c) 50.00%
(d) 2.781%

Answer _____

6. When a positron and an electron collide

- (a) neutrons are formed
(b) they strongly repel one another
(c) they annihilate and produce gamma-rays
(d) Such collisions never occur

Answer _____

7. Why are higher temperatures needed for He fusion than for H fusion?

- (a) He is chemically inert
- (b) He nuclei are heavier than H nuclei
- (c) He nuclei have a greater positive charge than H nuclei
- (d) Because $E = mc^2$

Answer _____

8. Creation of isotopes with mass numbers greater than 56 from ^{56}Fe

- (a) requires a particle accelerator
- (b) releases energy
- (c) is not possible
- (d) requires a net input of energy

Answer _____

9. Calculate the binding energy per nucleon for ^8Be given the following data: ^8Be isotopic mass = 1.32931×10^{-26} kg, proton mass = $1.67262158 \times 10^{-27}$ kg, neutron mass = $1.67492716 \times 10^{-27}$ kg, electron mass = $9.10938188 \times 10^{-31}$ kg, speed of light = 2.99792458×10^8 ms^{-1} .

- (a) 1.2035×10^{-6} J/nucleon
- (b) 1.08479×10^{-9} J/nucleon
- (c) 1.1317×10^{-12} J/nucleon
- (d) 9.0539×10^{-12} J/nucleon

Answer _____

10. A Geiger counter placed directly adjacent to a radioactive source gives a count rate of 1025 CPM. When a sheet of paper is interposed, the rate is 1019 CPM. When a thin sheet of Al foil is interposed, the rate is 825 CPM. When four such sheets are interposed, the rate is 421 CPM.

What type of radiation is the source emitting?

- (e) Alpha
- (f) Beta
- (g) Gamma
- (h) Electromagnetic

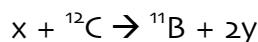
Answer _____

11. Over geologic timescales ($\sim 10^9$ years), how have the levels of background radiation from terrestrial sources changed?

- (a) They have remained roughly constant
- (b) They have decreased as radioisotopes have decayed.
- (c) They have increased as more elements became radioactive?
- (d) It is impossible to tell.

Answer _____

12. Balance the following equation



- (a) $x = {}^1_1\text{H}$, $y = {}^1_1\text{H}$
- (b) $x = {}^0_{-1}\text{e}$, $y = {}^0_{-1}\text{e}$
- (c) $x = {}^1_0\text{n}$, $y = {}^1_0\text{n}$
- (d) $x = {}^4_2\text{He}^{2+}$, $y = {}^4_2\text{He}^{2+}$

Answer _____

13. In 1925 Cecilia Payne discovered that the differences between stellar spectra were due primarily not to differences in elemental composition but in differences in ionization states of the elements as a result of higher or lower temperatures. The fact that the absorption and emission spectra of atoms and their ions are different is evidence that

- (a) the spectra are due to electrons
- (b) the spectra are due to protons
- (c) the spectra are due to neutrons
- (d) the spectra are due to the nuclei

Answer _____

14. EM radiation with a wavelength of 348 nm incident on an unknown metal surface causes ejection of photoelectrons with kinetic energies of 1.3×10^{-19} J. What is the unknown metal?

- (a) Rb ($\phi = 3.5 \times 10^{-19}$ J)
- (b) Au ($\phi = 8.2 \times 10^{-19}$ J)
- (c) Ni ($\phi = 8.3 \times 10^{-19}$ J)
- (d) Na ($\phi = 4.4 \times 10^{-19}$ J)

Answer _____

15. A buckyball (C_{60} molecule) in a molecular beam has a velocity of 220 m s^{-1} . If the mass of a C atom is 2.00×10^{-26} kg, what is the De Broglie wavelength of the buckyball molecule?

- (a) 2.52 pm
- (b) 2.52 fm
- (c) 2.52 m
- (d) 1.20 pm

Answer _____

16. The Rydberg equation can be modified to work for any ion, provided it has only one electron. The modified equation is

$$\Delta E = -(2.18 \times 10^{-18} \text{ J}) Z^2 (1/n_1^2 - 1/n_2^2)$$

where Z is the charge of the nucleus. Which of the following ions will have the longest wavelength emission line for the transition between the $n_1 = 2$ and $n_2 = 1$ levels?

- (a) He^+
- (b) Li^{2+}
- (c) Ne^{9+}
- (d) U^{91+}

Answer _____

17. Which of the following is an allowable set of quantum numbers for a 2p electron?

- (a) $n=2, l=0, m_l=0, m_s=1/2$
- (b) $n=2, l=1, m_l=0, m_s=1/2$
- (c) $n=2, l=0, m_l=0, m_s=-1/2$
- (d) $n=2, l=1, m_l=1/2, m_s=1/2$

Answer _____

18. Which of the following ions is/are isoelectronic with Kr: (I) Kr^+ , (II) Rb^+ , (III) K^+ , (IV) I^- , (V) Br^- , (VI) Sr^{2+} ?

- (a) (I) only
- (b) (II) only
- (c) (II) and (IV)
- (d) (II), (IV), and (V)
- (e) (II), (V), and (VI)
- (f) none of them

Answer _____

19. Which of the following contains the largest number of H atoms?

- (a) 1.0 mol of H_2
- (b) 0.75 mol of NH_3
- (c) 0.25 mol of C_2H_6
- (d) 0.5 mol of CH_4

Answer _____

20. If 6 L of H_2 gas are combined with 2.5 L of N_2 gas at a constant pressure of 1 atm, and the reaction goes to completion according to the equation $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$, what will the total final volume of gas be after reaction?

- (a) 2.0 L
- (b) 2.5 L
- (c) 4.5 L
- (d) 8.5 L

Answer _____

21. When bottles of hydrochloric acid and ammonia are stored close together, a white dusty film forms around the bottles. The film is (probably)
- (a) Ammonic acid
 - (b) Hydrogen ammoniate
 - (c) Ammonium chloride
 - (d) Ammonium chlorate

Answer _____

22. A beaker containing 75.0 mL of saltwater was left to evaporate, and the beaker plus dry NaCl residue weighed 65.665 g. The dry weight of the beaker was 65.160 g. What was the concentration of the original solution.

- (a) 0.00647 M
- (b) 0.0115 M
- (c) 0.0673 M
- (d) 0.115 M

Answer _____

23. Which solution will have the lowest osmotic pressure when measured against pure water?

- (a) 0.10 M sodium chloride
- (b) 0.10 M sodium sulfate
- (c) 0.10 M sodium sulfide
- (d) 0.10 M sodium phosphate

Answer _____

24. If 1L of spilled 1 M HCl needed to be neutralized using sodium carbonate, how many grams of the solid would be required?

- (a) 53 g
- (b) 83 g
- (c) 106 g
- (d) 166 g

Answer _____

25. Which of the following molecules/ions contains an exception to the octet rule?

- (a) O_2
- (b) SO_4^{2-}
- (c) CS_2
- (d) XeF_4

Answer _____

26. Which of the following predictions based on the Lewis structure of O_2 is/are incorrect?

- (a) O_2 contains a double bond
- (b) O_2 contains 12 valence electrons
- (c) O_2 has no dipole moment
- (d) O_2 contains no unpaired electrons

Answer _____

27. Which of the following molecules/ions requires resonance structures for its correct representation?

- (a) PCl_5
- (b) CO_2
- (c) C_6H_6
- (d) C_6H_{14}

Answer _____

28. What is the formal charge of the N atom in hydrogen cyanide, HCN?

- (a) -1 (b) 0 (c) 1 (d) 5

Answer _____

29. Which type of molecular orbital has cylindrical (i.e. rotation round the bond axis) symmetry, and a buildup of electron density between the nuclei?

- (a) σ (b) π (c) σ^* (d) π^*

Answer _____

30. Odd-electron atoms/molecules are called

- (a) cations
(b) anions
(c) radicals
(d) ions

Answer _____

31. The inverse correlation between the stratospheric concentrations of ozone and CFCs shows that

- (a) there is a hole in the ozone layer
(b) ozone reacts with CFCs
(c) ozone reacts with Cl atoms
(d) ozone is decomposed by UV

Answer _____

32. Which of the following is T-shaped?

- (a) NCl_3 (b) PCl_3 (c) SCl_3 (d) ICl_3

Answer _____

33. What are the hybridizations of the carbon atoms in CH_3CHCH_2 ?

- (a) $\text{sp}^3, \text{sp}^3, \text{sp}^3$
(b) $\text{sp}^3, \text{sp}^2, \text{sp}$
(c) $\text{sp}^2, \text{sp}^3, \text{sp}^2$
(d) $\text{sp}^3, \text{sp}^2, \text{sp}^2$

Answer _____

34. Which of these molecules is polar?

- (a) CF_4 (b) SiH_4 (c) CHCl_3 (d) CS_2

Answer _____

35. If the volume of a container enclosing an ideal gas is halved, and its temperature in kelvin is also halved, the pressure inside the container

- (a) doubles
(b) is halved
(c) is unchanged
(d) is reduced by a factor of four

Answer _____

36. Calcium carbonate decomposes according to the equation $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$. If 2.5 g of calcium carbonate is decomposed in an evacuated 1L container at a temperature of 900°C , what is the pressure in the container after the reaction is complete?

- (a) 130 kPa (b) 187 kPa
(c) 244 kPa (d) 244 Pa

Answer _____

37. Helium-neon lasers contain a low-pressure mixture of helium and neon gases. By what factor is the root-mean-square speed v_{rms} of the He atoms greater than that of the Ne atoms in this mixture?

(a) 5 (b) 2.2 (c) 0.5 (d) 0.2

Answer _____

38. Which of the following gases should have the largest Van der Waals "a" coefficient?

(a) Ar (b) N₂ (c) H₂O (d) CH₄

Answer _____

39. Which of the following classes of intermolecular interactions are relevant for CH₃Cl?

(I) London forces
(II) dipole-dipole interactions
(III) hydrogen bonding

(a) (I) only
(b) (I) and (II)
(c) (I), (II), and (III)
(d) (I) and (III)

Answer _____

40. Which of the following pairs of liquids are likely to be miscible?

(a) H₂O and C₆H₁₄
(b) H₂O and CCl₄
(c) Br₂ and HI
(d) Br₂ and CCl₄

Answer _____

END OF EXAMINATION