Physical Chemistry

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1. A first order reaction has a rate constant $k = 0.0230\,\mathrm{s}^{-1}$. What is its half-life?

   - $0.0230\,\mathrm{s}$
   - $45.2\,\mathrm{s}$
   - $30.1\,\mathrm{s}$
   - $15.0\,\mathrm{s}$

2. The reaction between hydrogen and iodine to form hydrogen iodide follows second-order kinetics with rate law $\mathrm{rate} = k[\mathrm{H_2}][\mathrm{I_2}]$. If the concentration of both reactants is doubled, what happens to the reaction rate?

   - The rate doubles.
   - The rate quadruples.
   - The rate is squared.
   - The rate does not change.

3. According to the Arrhenius equation, what effect does an increase in temperature have on the rate constant of a reaction?

   - Increases the activation energy
   - Increases the rate constant
   - Has no effect on the rate constant
   - Decreases the rate constant

4. For the reversible reaction $\mathrm{N_2O_4\,(g)} \rightleftharpoons 2\,\mathrm{NO_2\,(g)}$, if the volume of the container is decreased, which direction will the equilibrium shift?

   - Shift to the left (towards reactants)
   - Increase in the equilibrium constant

- Shift to the right (towards products)
- No shift in equilibrium

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5. What is the effect on the pH when a strong acid is diluted 100-fold?

- pH increases by one unit
- pH increases by two units
- pH remains unchanged
- pH decreases by two units

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6. Using Hess's Law, if Reaction A has an enthalpy change of $+50\,\mathrm{kJ}$ and Reaction B has an enthalpy change of $-30\,\mathrm{kJ}$, what is the overall enthalpy change for the sequence (A followed by B)?

- $-20\,\mathrm{kJ}$
- $+20\,\mathrm{kJ}$
- $-80\,\mathrm{kJ}$
- $+80\,\mathrm{kJ}$

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7. Which statement about Gibbs free energy (ΔG) is correct for a spontaneous process at constant temperature and pressure?

- $\Delta G > 0$
- It is not defined for spontaneous processes
- $\Delta G = 0$
- $\Delta G < 0$

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8. Two reactions have different activation energies. With a small temperature increase, which reaction will exhibit a greater relative increase in its rate constant?

- Both rate constants increase by the same percentage, regardless of activation energy
- The reaction with the lower activation energy has a greater percentage increase in the rate constant
- Temperature has no effect on the rate constant
- The reaction with the higher activation energy has a greater percentage increase in the rate constant

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9. Given the half-reactions

$$\mathrm{Cu^{2+} + 2\,e^- \longrightarrow Cu} \quad (E^\ominus = +0.34\,\mathrm{V})$$

$$\mathrm{Zn^{2+} + 2\,e^- \longrightarrow Zn} \quad (E^\ominus = -0.76\,\mathrm{V}),$$

what is the standard cell potential for the electrochemical cell where copper(II) ions are reduced to copper, and zinc is oxidised to zinc(II) ions? Give your answer to 2 decimal places.

- $+1.10\,\mathrm{V}$
- $+0.42\,\mathrm{V}$
- $-0.42\,\mathrm{V}$
- $-1.10\,\mathrm{V}$

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10. For an endothermic reaction, how does an increase in temperature affect the equilibrium constant, K?

- K can increase or decrease, depending on the entropy change for the reaction.
- K decreases.
- K increases.
- K remains unchanged.

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11. A gas occupies $2.5\,\mathrm{dm}^3$ at $500\,\mathrm{K}$ and $5.0 \times 10^5\,\mathrm{Pa}$. Assuming the gas can be modelled using the ideal gas law, approximately how many moles of gas are present?

- $0.20\,\mathrm{mol}$
- $0.40\,\mathrm{mol}$
- $0.10\,\mathrm{mol}$
- $0.30\,\mathrm{mol}$

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12. How does a catalyst affect a chemical equilibrium?

- A catalyst shifts the position of equilibrium to the exothermic side.
- A catalyst shifts the position of equilibrium to the side with more moles of gas.
- A catalyst makes it impossible to reach chemical equilibrium.
- A catalyst does not affect the position of equilibrium, but means equilibrium is reached faster.

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Inorganic Chemistry

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13. According to VSEPR theory, what is the molecular shape of $\mathrm{SF_4}$?

- Square pyramidal
- Seesaw
- Trigonal bipyramidal
- Tetrahedral

14. What is the electron configuration of $\mathrm{Fe^{2+}}$?

- $[\mathrm{Ar}]\ 4\mathrm{s}^1\ 3\mathrm{d}^5$
- $[\mathrm{Ar}]\ 4\mathrm{s}^2\ 3\mathrm{d}^4$
- $[\mathrm{Ar}]\ 4\mathrm{s}^2\ 3\mathrm{d}^6$
- $[\mathrm{Ar}]\ 3\mathrm{d}^6$

15. How does the atomic radius change across a period in the periodic table?

- Fluctuates unpredictably
- Increases
- Decreases
- Remains constant

16. Which of the following molecules is most likely to exhibit a dipole moment due to its shape?

- $\mathrm{H_2O}$
- $\mathrm{BF_3}$
- $\mathrm{CO_2}$
- $\mathrm{CH_4}$

17. What trend is observed for the first ionisation energy as one moves down a group in the periodic table?

- Decreases
- First increases then decreases
- Remains constant
- Increases

18. Which property is characteristic of metals in terms of electrical conductivity?

- High conductivity in the solid state only
- High conductivity in the molten state only
- High conductivity in both solid and molten states
- No conductivity in either state

19. What is the oxidation state of chromium in the dichromate ion $\mathrm{Cr_2O_7}^{2-}$?

- +6
- +3
- +7
- +2

20. Which type of bonding involves the sharing of electron pairs between atoms?

- Ionic bonding
- Covalent bonding
- Metallic bonding
- Van der Waals forces

21. Why do ionic compounds conduct electricity when molten?

- Because ions are free to move
- Because the nuclei no longer interact with electrons
- Because of the intermolecular forces present
- Because they have free electrons

22. In coordination chemistry, what is the process called when a water molecule in a hexaaqua complex is replaced by an ammonia molecule?

- Oxidation
- Hydrolysis
- Reduction
- Ligand substitution

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23. Which of the following electron configurations corresponds to a halogen element?

- $[\mathrm{Ne}]\ 3\mathrm{s}^2\ 3\mathrm{p}^4$
- $[\mathrm{Ne}]\ 3\mathrm{s}^2\ 3\mathrm{p}^3$
- $[\mathrm{Ne}]\ 3\mathrm{s}^2\ 3\mathrm{p}^2$
- $[\mathrm{Ne}]\ 3\mathrm{s}^2\ 3\mathrm{p}^5$

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24. How does the first ionisation energy change when crossing Period 3 from left to right?

- The first ionisation energy generally (with a few exceptions) increases due to an increase in nuclear charge resulting in a stronger attraction between the nucleus and outer electrons.
- The first ionisation energy generally (with a few exceptions) remains constant because the increase in the number of electrons exactly balances the increase in the number of protons.
- The first ionisation energy first decreases as more protons are added but then increases as the effect of adding more electrons becomes dominant.
- The first ionisation energy generally (with a few exceptions) decreases due to greater shielding/electron-electron repulsion from the increasing number of electrons.

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