Subject knowledge tests: post-16 chemistry

Test 2: questions

For each question, select the correct answer – A, B, C or D.

1 Which statement offers a correct definition for an acid?

An acid ...

A ... is a proton donor.

B ... is a proton acceptor.

C ... is fully ionised in water to produce $\text{H}^+(aq)$.

D ... is reduced during a neutralisation reaction.

2 Which response gives the correct overall charges on these complex ions?

Tetrachlorocupro(II) [$\text{CuCl}_4$]

Hexacyanoferrate(III) [$\text{Fe(CN)}_6$]

Hexa-amminenickel(II) [$\text{Ni(NH}_3\text{)}_6$]

<table>
<thead>
<tr>
<th></th>
<th>[CuCl₄]</th>
<th>[Fe(CN)₆]</th>
<th>[Ni(NH₃)₆]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2⁺</td>
<td>3⁻</td>
<td>2⁻</td>
</tr>
<tr>
<td>B</td>
<td>2⁻</td>
<td>3⁻</td>
<td>2⁺</td>
</tr>
<tr>
<td>C</td>
<td>4⁻</td>
<td>6⁻</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>2⁺</td>
<td>3⁺</td>
<td>2⁺</td>
</tr>
</tbody>
</table>
3 What is the enthalpy change of combustion occurring when one mole of ethane gas burns in oxygen?

\[ \text{C}_2\text{H}_6(\text{g}) + 3.5\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l}) \]

Bond enthalpy values (kJ mol\(^{-1}\)):

\[ \text{C–C} = +347; \quad \text{C–H} = +413; \quad \text{O=O} = +498; \quad \text{C=O} = +805; \quad \text{H–O} = +464 \]

A
\[ \Delta H_C = -(6 \times 413) - 347 - (3.5 \times 498) + (4 \times 805) + (6 \times 464) \]

B
\[ \Delta H_C = +(6 \times 413) + 347 + 498 - (2 \times 805) - (3 \times 464) \]

C
\[ \Delta H_C = +(6 \times 413) + 347 + (3.5 \times 493) - (4 \times 805) - (6 \times 464) \]

D
\[ \Delta H_C = -413 - 347 - 498 + 805 + 464 \]

4 What is meant by the activation energy required for a reaction?

A The minimum amount of energy required to initiate a chemical reaction.

B The energy required to break specific bonds to start a chemical reaction.

C The minimum amount of energy involved for a successful collision between two molecules.

D The maximum kinetic energy required for a reaction to proceed.

5 How is \( K_c \) for any equilibrium mixture affected when changes to reaction conditions occur?

A \( K_c \) is a constant so cannot be changed under any circumstances.

B \( K_c \) changes only when temperature changes.

C \( K_c \) changes only when pressure changes.

D \( K_c \) changes only when a catalyst is present.
Here is a general rate equation for the reaction shown:

\[ aA + bB \rightarrow cC + dD \]

Rate = \( k \cdot [A]^m \cdot [B]^n \)

Which statement about rate equations is correct?

A. \( k, n \) and \( m \) can only be determined by experiment.

B. \( m = a \) and \( n = b \).

C. A rate equation is independent of the temperature at which the reaction occurs.

D. The rate constant, \( k \), changes when a catalyst is present.

In a closed fizzy-drink bottle an equilibrium position exists between carbon dioxide gas in the head space above the drink and carbon dioxide in the drink itself:

\[ \text{CO}_2(g) \rightleftharpoons \text{CO}_2(aq) \]

The “fizz” of a fizzy drink can be kept for several hours by using a “fizz-keeper” in place of a bottle cap. Air is pumped into the bottle after pouring out a drink. Which statement best explains how a fizz-keeper works?

A. The equilibrium position re-establishes more quickly.

B. The increased overall pressure slows down the rate at which the carbon dioxide molecules diffuse from the drink.

C. The equilibrium shifts to the right, with air instead of \( \text{CO}_2 \).

D. The extra air makes up the volume lost by pouring out the drink.
Here is the equation for the reaction between two complex ions:

$$\text{Co(H}_2\text{O)}_{6}^{2+} + 4\text{Cl}^- \rightleftharpoons \text{CoCl}_4^{2-} + 6\text{H}_2\text{O}$$

PINK (cobalt(II) hexahydrate complex ion)
BLUE (cobalt(II) tetrachloro complex ion)

Two test tubes, one containing a solution of only the pink complex ion, and the other a solution of only the blue complex ion, are placed in a water bath at 60 °C. After 5 mins, both tubes contained purple solutions. Which statement best explains this observation?

A The forward reaction is exothermic.
B The reverse reaction is exothermic.
C Both reactions are endothermic.
D Both reactions are occurring simultaneously in both tubes.

Which of the following statements about concentration and strength of an acid/alkali is true?

A Concentration measures the amount of acid/alkali in a given volume.
B Strength measures the amount of acid/alkali in a given volume.
C Concentration measures the degree of ionisation in solution.
D Strength measures the rate at which acids and alkalis react.

What is produced when propanone (CH₃COCH₃) reacts with hydrogen cyanide (HCN)?

A 2-Hydroxy-2-methylpropanenitrile CH₃CH(OH)(CH₃)CN
B Propanocyanohydrin, CH₃CH₂(CH₃)CN, OH⁻ ions
C Propanal, CH₃CHOCH₃, CN⁻ ions
D Butanocyanohydrin, CH₃COCH₂CN, hydrogen, H₂
11. Which response gives the correct systematic names for these two compounds?

\[
\begin{align*}
\text{CH}_3\text{CH(CH}_3\text{)CH(OH)CH}_3 & \quad \text{CH}_3\text{CH(CH}_3\text{)CH}_2\text{COOH} \\
\end{align*}
\]

A 1-methylbutan-2-ol 1-methylpentanoic acid  
B 2-methylbutan-3-ol 3-methylpentanoic acid  
C 3-methylbutan-2-ol 3-methylbutanoic acid  
D pentan-2-ol pentanoic acid

12. What volume of oxygen is required to completely burn 570 g octane, C\textsubscript{8}H\textsubscript{18}?

\[
\text{C}_8\text{H}_{18} + 12.5\text{O}_2 \rightarrow 8\text{CO}_2 + 9\text{H}_2\text{O}
\]

Ar values: H = 1, O = 16, C = 12; assume 1 mole of gas occupies 24 dm\textsuperscript{3} 

A \frac{570}{114} \times 12.5 \times 24  
B \frac{114}{570} \times 12.5 \times 24  
C \frac{570}{114} \times 24  
D 12.5 \times 24

13. Which is the best description of the bonding between sodium and chloride ions in sodium chloride?

A They are held by electrostatic attractions in a 3-D lattice in a 1:1 ratio.  
B Ionic bonds form NaCl molecules which are held by electrostatic attractions in a 3-D lattice.  
C The positive and negative ions alternate throughout a 3-D cubic crystal.  
D The ions form NaCl molecules which alternate throughout a 3-D cubic crystal.
14 Use the expression:

\[ K_a = [H^+(aq)][A^-(aq)] / [HA(aq)] \]

to calculate the pH of a solution of ethanoic acid, concentration 1 mol dm\(^{-3}\)

(K\(_a\) ethanoic acid = 1.7 × 10\(^{-5}\) mol dm\(^{-3}\) at 298 K)

\[ \text{pH of 1 mol dm}^{-3} \]

A 3.39
B 1.7
C 2.38
D 4.12

15 Here is the equation for the reaction between methane and oxygen:

\[ \text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g) \quad \Delta H = -\text{ve} \]

What does "\(\Delta H = -\text{ve}\)" tell you about the activation energy?

A The reaction has a high activation energy.
B The reaction has a negative activation energy.
C The reaction has a low activation energy.
D It gives no information about activation energy.
Here is an enthalpy cycle:

\[
\begin{align*}
C(s) + 2H_2(g) & \quad \Delta H_1 \quad \text{CH}_4(g) \\
2O_2(g) & \quad \Delta H_2 \quad \text{CO}_2(g) + 2H_2O(l) \\
& \quad \Delta H_3 \quad +2O_2(g)
\end{align*}
\]

Which statement will give the correct value of $\Delta H_1$?

A $\Delta H_1 = 393 + 286 - 890$

B $\Delta H_1 = -393 - 286 + 890$

C $\Delta H_1 = -393 - (2 \times 286) + 890$

D $\Delta H_1 = 393 + (2 \times 286) - 890$

Here are two lattice enthalpy values (kJ mol\(^{-1}\)) for Period 1 oxides:

Li\(_2\)O $\quad -2806$

Al\(_2\)O\(_3\) $\quad -15916$

What is the best explanation for the difference in lattice enthalpy values?

A The aluminium ion has a higher charge.

B Aluminium combines with three oxide ions.

C Aluminium is more reactive than lithium.

D Lithium is more reactive than aluminium.
18 Why does sodium chloride have the formula NaCl but magnesium chloride has the formula MgCl₂?
A These formulae correspond to the valencies of sodium and magnesium.
B These formulae represent the ways that all atoms involved can have full electron shells.
C These are the most energetically favourable ratios for the ions involved.
D The valencies of sodium, magnesium and chlorine are satisfied by these formulae.

19 When calcium hydroxide solution and hydrochloric acid react, the equation is:
Ca(OH)₂(aq) + 2HCl(aq) → CaCl₂(aq) + 2H₂O(l)
In a titration, 25 cm³ calcium hydroxide solution reacted with 23 cm³ 0.5 mol dm⁻³ hydrochloric acid.
What is the concentration (mol dm⁻³) of the calcium hydroxide solution?
A \( \frac{0.5 \times 25}{1000} \)
B \( \frac{23}{1000} \times 0.5 \times 2 \times 1000 / 25 \)
C \( \frac{23}{1000} \times 0.5 \times 0.5 \times 1000 / 25 \)
D \( \frac{0.5 \times 23}{1000 \times 25 / 1000} \)

20 Which reaction mechanism is characteristic of compounds containing a benzene ring?
A Electrophilic addition
B Nucleophilic addition/elimination
C Electrophilic substitution
D Nucleophilic substitution
21 What particles are present in sodium hydroxide solution, NaOH(aq)?

A NaOH, H₂O
B Na⁺, OH⁻, H⁺, H₂O
C NaO⁻, H⁺
D Na⁺, H⁺, OH⁻

22 How does the solubility of Group 2 hydroxides change from magnesium to barium?

A Increases down the group.
B Decreases down the group.
C Stays the same.
D Increases to calcium then decreases.

23 Which statement best explains why Group 1 elements feature at the peaks in a graph of atomic radius against atomic number?

A Group 1 elements have larger atomic volumes than other elements.
B Metallic bonds between Group 1 metal atoms are weak.
C Group 1 metals have the lowest first ionisation enthalpies of all elements.
D Single outer shell electrons of Group 1 metal atoms are less tightly bound than those of other elements.

24 Which statement is the best definition of a d-block element?

An element with atoms that ...

A ... have a full 4s electron shell, but partially filled d-shell.
B ... have a partially filled d-shell.
C ... form an ion with a partially filled d sub-shell.
D ... form two or more ions with variable oxidation states.
25 Which statement best represents enthalpy change of solution?

A \[ \Delta H_{\text{solution}} = -\Delta H^o_{LE} + \Delta H_{\text{hydration}}(\text{cation}) + \Delta H_{\text{hydration}}(\text{anion}) \]

B \[ \Delta H_{\text{solution}} = \Delta H^o_{LE} + \Delta H_{\text{hydration}}(\text{cation}) + \Delta H_{\text{hydration}}(\text{anion}) \]

C \[ \Delta H_{\text{solution}} = \Delta H^o_{LE} - \Delta H_{\text{hydration}}(\text{cation}) - \Delta H_{\text{hydration}}(\text{anion}) \]

D \[ \Delta H_{\text{solution}} = -\Delta H^o_{LE} - \Delta H_{\text{hydration}}(\text{cation}) - \Delta H_{\text{hydration}}(\text{anion}) \]

26 What is produced in the reaction occurring when excess concentrated ammonia solution is heated in a sealed tube with bromobutane?

\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + 2\text{NH}_3 \rightarrow ? \]

A Butylamine

B Butylamine, ammonium bromide

C Bromobutylamine

D 1-Bromo-2-aminobutane

27 Titanium(IV) chloride, TiCl₄, is covalently bonded and magnesium chloride, MgCl₂, is ionically bonded. They are mixed and heated to 1000 °C. The vapour only contains titanium(IV) chloride molecules. This is because:

A Covalent bonds are weaker than ionic bonds so break more easily at high temperatures.

B Covalent bonds are stronger than ionic bonds so the TiCl₄ molecules stay whole.

C Ionic compounds have higher boiling points than covalent compounds.

D Intermolecular bonds between covalently bonded molecules are weaker than attractions between ions.
A reaction has the general equation $2A + B \rightarrow C + D$

The rate of reaction was investigated by varying the concentration of the two reactants. The table shows the initial concentrations of the reactants and the relative rate of reaction.

<table>
<thead>
<tr>
<th>[A]</th>
<th>[B]</th>
<th>relative rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>1.0</td>
<td>0.5</td>
<td>8</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>8</td>
</tr>
<tr>
<td>1.5</td>
<td>1.5</td>
<td>18</td>
</tr>
</tbody>
</table>

What are the orders of reaction with respect to A and B?

<table>
<thead>
<tr>
<th>[A]</th>
<th>[B]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
</tr>
</tbody>
</table>

Which equation represents the first ionisation enthalpy for an oxygen atom?

A $\text{O}(g) + e \rightarrow \text{O}^-(g)$

B $\text{O}(g) \rightarrow \text{O}^+(g) + e^-$

C $\text{O}_2(g) \rightarrow \text{O}^2+(g) + e^-$

D $\text{O}_2(g) + 2e^- \rightarrow \text{O}^{2-}$
30 The main reaction in the contact process is:

\[2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -\text{ve}\]

What conditions help produce the maximum yield of sulfur trioxide?

A High pressure and high temperature.

B High pressure and low temperature.

C Low pressure and low temperature.

D Low pressure and high temperature.

31 When magnesium and oxygen react, a white solid is produced and light and heat are emitted.

\[\text{Mg}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{MgO}(\text{s})\]

Which of these statements is correct?

A \(\Delta H\) is \(-\text{ve}, \Delta S\) is \(+\text{ve}\)

B \(\Delta H\) is \(+\text{ve}, \Delta S\) is \(+\text{ve}\)

C \(\Delta H\) is \(-\text{ve}, \Delta S\) is \(-\text{ve}\)

D \(\Delta H\) is \(+\text{ve}, \Delta S\) is 0
The graph shows how rate of reaction changes over time for the decomposition of hydrogen peroxide. At which point, A, B, C or D, is the reaction complete?