Test 3 Redox and Chemical Analysis

Multiple Choice (10 marks - 1 for each question)

1. Which of the following is a redox reaction?

A  $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
B  $\text{MgO} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O}$
C  $\text{MgCO}_3 + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
D  $\text{Mg(OH)}_2 + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O}$

2. During a redox process in acid solution, iodate ions, $\text{IO}_3^-$ (aq) are converted into iodine $\text{I}_2$ (aq).

$\text{IO}_3^-(aq) \rightarrow \text{I}_2 (aq)$

The numbers of $\text{H}^+$ (aq) and $\text{H}_2\text{O}(l)$ required to balance the ion electron equation for the formation of 1 mole of $\text{I}_2$ (aq) are, respectively

A  3 and 6
B  6 and 3
C  6 and 12
D  12 and 6

3. The ion-electron equations for a redox reaction are

$2\text{I}^- (aq) \rightarrow \text{I}_2 (aq) + 2e$
$\text{MnO}_4^- (aq) + 8\text{H}^+ (aq) + 5e \rightarrow \text{Mn}^{2+} (aq) + 4\text{H}_2\text{O} (l)$

How many moles of iodide ions are oxidised by one mole of permanganate ions?

A  0.2
B  0.4
C  2
D  5

4. In which of the following reactions in a positive ion reduced?

A  Iodide $\rightarrow$ iodine
B  Nickel(II) $\rightarrow$ nickel (III)
C  Cobalt (III) $\rightarrow$ cobalt (II)
D  Sulphate $\rightarrow$ sulphite
5. In which of the following reactions is the hydrogen ion acting as an oxidising agent.

A  Mg + 2HCl → MgCl₂ + H₂
B  NaOH + HNO₃ → NaNO₃ + H₂O
C  CuCO₃ + H₂SO₄ → CuSO₄ + H₂O + CO₂
D  CH₃COONa + HCl → NaCl + CH₃COOH

6. During a redox reaction dichromate ions are oxidised to chromium ions.

Cr₂O₇²⁻(aq) + 14H⁺(aq) + xe → 2Cr³⁺(aq) + 7H₂O(l)

To balance the equation, what is the value of x?

A  4
B  6
C  9
D  14

7. Some pieces of equipment are shown below.

You are asked to measure accurately the volume of carbon dioxide produced every minute when chalk and acid react together.

Which of the following combinations of pieces of equipment is the best one to use?

A  P and Q
B  S and Q
C  P and R
D  S and R
8. Aluminium carbonate can be produced by the following reaction.
\[ 2\text{AlCl}_3 (\text{aq}) + 3\text{K}_2\text{CO}_3 (\text{aq}) \rightarrow \text{Al}_2(\text{CO}_3)_3 (\text{s}) + 6\text{KCl (aq)} \]

The most suitable method of obtaining a sample of the aluminium carbonate is
A  collection over water  
B  distillation  
C  evaporation  
D  filtration

9. 45cm\(^3\) of a solution could be most accurately measured out using a
A  50cm\(^3\) measuring cylinder  
B  50cm\(^3\) pipette  
C  50cm\(^3\) burette  
D  50cm\(^3\) beaker

10. Sulfur dioxide gas is more dense than air and is very soluble in water.

Which of the following shows the most appropriate apparatus for collection and measuring the volume of sulfur dioxide given of in a reaction?

A  
B  
C  
D  

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Written Part  (20 marks)

11. Zinc is an essential element for the body and is found in a variety of foods.

(a) The mass of zinc in four 110g samples taken from a cheese spread was measured.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mass of Zn/mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>2</td>
<td>21.7</td>
</tr>
<tr>
<td>3</td>
<td>3.9</td>
</tr>
<tr>
<td>4</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Calculate the average mass of Zn, in mg, in 100g of this cheese spread.  

(b) The recommended daily allowance of zinc is 8.5mg for an adult female. 100g of peanuts contains 3.3mg of zinc. Calculate the mass of peanuts which would provide the recommended daily allowance.

12. A student carried out an investigation to measure the nitrite level in the school water supply. A compound, which reacts with the nitrite ions to form a product that absorbs light, is added to water samples. The higher the concentration of nitrite ions present in the water sample, the greater the amount of light absorbed.

(a) The student prepared potassium nitrite solutions of known concentration by diluting samples from a stock solution.

(i) 462.5mg, of potassium nitrite, KNO$_2$, is needed to make up 1 litre of stock solution with a nitrite ion concentration of 250 mg$^{-1}$. Describe how the weighed potassium nitrite is dissolved to prepare the stock solution to ensure that its concentration is accurately known.

(ii) Why should the student use distilled water or deionised water rather than tap water when dissolving the potassium nitrite?

(iii) To prepare a solution with a nitrite ion concentration of 0.05 mg$^{-1}$ the student dilutes the stock solution. Why is this method more accurate than preparing a solution by weighing out potassium nitrite?
(b) The graph below shows results for five solutions of potassium nitrite and a sample of distilled water.

The results for four tap water samples are shown below.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Absorbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>0.09</td>
</tr>
<tr>
<td>Two</td>
<td>0.09</td>
</tr>
<tr>
<td>Three</td>
<td>0.33</td>
</tr>
<tr>
<td>Four</td>
<td>0.09</td>
</tr>
</tbody>
</table>

What is the concentration of nitrite ions, in mg/l, in the tap water?

13. Potassium permanganate is a very useful chemical in the laboratory.

(a) Solid potassium permanganate can be heated to release oxygen gas. This reaction can be represented by the equation shown below.

\[ \text{KMnO}_4 (s) \rightarrow \text{K}_2\text{O} (s) + \text{MnO}_2 (s) + \text{O}_2 (g) \]

Rewrite the above equation and balance it.

(b) An acidified potassium permanganate solution can be used to determine the concentration of a solution of iron (II) sulphate by a titration method.

(i) Apart from taking accurate measurements, suggest two points of good practice that a student should follow to ensure that an accurate end-point is achieved in a titration.

(ii) In a titration, a student found that an average of 16.7 cm\(^3\) of iron (II) sulphate solution was needed to react completely with 25.0 cm\(^3\) of 0.20 mol/l potassium permanganate. The equation for the reaction is:

\[ 5\text{Fe}^{2+} (aq) + \text{MnO}_4^- (aq) + 8\text{H}^+ (aq) \rightarrow 5\text{Fe}^{3+} (aq) + \text{Mn}^{2+} (aq) + 4\text{H}_2\text{O} (l) \]

Calculate the concentration of the iron (II) solution, in mol/l
14. A standard solution of iodine can be used to determine the mass of Vitamin C in orange juice.
Iodine reacts with Vitamin C as shown by the following equation.

\[ \text{C}_6\text{H}_8\text{O}_6 (aq) + \text{I}_2 (aq) \rightarrow \text{C}_6\text{H}_6\text{O}_6 (aq) + 2\text{H}^+ + 2\text{I}^- (aq) \]

Vitamin C

In an investigation using a carton containing 500 cm\(^3\) of orange juice, separate 50.0 cm\(^3\) samples were measured out. Each sample was then titrated with a 0.005 mol\(^-1\) solution of iodine.

(i) Why would starch solution be added to each 50.0 cm\(^3\) sample of orange juice before titrating against iodine solution? 1

(ii) Titrating the whole carton of orange juice would require large volumes of iodine solution. Apart from this disadvantage give another reason for titrating several smaller samples of orange juice. 1

(iii) An average of 21.4 cm\(^3\) of the iodine was required for the complete reaction with the vitamin C in 50.0 cm\(^3\) of orange juice. Use this result to calculate the mass of vitamin C, in grams, in the 500 cm\(^3\) carton of orange juice. (GFM of vitamin C = 176g) 2

15. When forensic scientists analyse illegal drugs, analgetics such as lidocaine are sometimes found to be present. The gas chromatogram below is from an illegal drug.
(a) The structure of benzocaine and tetracaine are shown below.

Suggest why benzocaine has a shorter retention time than tetracaine.

(b) Why is it difficult to obtain accurate values for the amount of lidocaine present in a sample containing large amounts of caffeine?

(b) Draw a sketch of the chromatogram below and add a peak for a second sample that only contains half the amount of tetracaine compared to the first.
Marking Scheme

1. A
2. D
3. D
4. C
5. A
6. B
7. B
8. D
9. C
10. D

11. (a) 4 or 4.0
   (b) 257.6g

12. (a) 
    (i) mention of transfer of rinsings (1 mark)
         making up to the mark of standard/volumetric flask (1 mark)
    (ii) tap water could contain nitrites (1 mark)
         Or
         Distilled water will not contain nitrites (1 mark)
         Mention of nitrites required for this mark
    (iii) Mass required to make 250 cm³ of 0.05 mg l⁻¹ solution is too small to weigh accurately

13. (a) 2KMnO₄(s) → K₂O (s) + 2MnO₂ (s) + 1½O₂ (g)
   (b) Repeat experiment, concordant results/ white tile underflask.
       Any two for 1 mark.
   (i) Moles permanganate = 0.2 x 0.025 = 0.005
       Moles of Fe³⁺ = 0.005 x 5 = 0.025
       Concentration of Fe³⁺ = 0.025/0.0167 = 1.50 moll⁻¹

14. (i) As an indicator (to show excess iodine present)
   (ii) Concordant results then average taken
   (iii) Moles of iodine = 0.005 x 0.0214 = 1.07x10⁻⁴. 1 mole iodine to 1 mole of Vit C
         Moles of Vitamin C = 1.07x10⁻⁴ in 50cm³ → Moles in 500cm³= 1.07 x10⁻³
         Mass of Vit C in 500 cm³ = 176 x 1.07x10⁻³ = 0.19g

15. (a) Any of answers below
    Benzocaine is a smaller/Tetracaine is bigger
    weaker London Dispersion Forces /Van der Waal’s forces with Benzocaine
    Benzocaine has lower b.pt
    Benzocaine more soluble/attracted in/ to mobile phase
    Benzocaine less strongly attracted to stationary phase
    Benzocaine is more polar
(b) The peaks for lidocaine and caffeine overlap  
   or Candidate wording for idea of masking  
(c) Peak for tetracaine at correct RT with approximately half original height