*TEACHER DEVELOPMENT CENTRE CHEMISTRY*

**3BCHE CHEMISTRY**

**TEST 6. REDOX AND ELECTROCHEMICAL CELLS – MARKS 60**

**Areas covered in this test:** Common oxidising and reducing agents; assigning oxidation numbers; balancing redox equations; performing calculations on redox titrations; redox volumetric analysis procedures; constructing electrochemical cells; calculating the cell potentials; commercial cells.

**Instructions to students**: This test consists of three sections. Section 1 consists of fifteen (15) multiple choice questions. Section 2 consists of 6 short-answer questions. Section 3 consists of 3 calculations. Attempt *all* the questions.

**Section 1. Multiple Choice questions**: Mark your selected answer for each question in the “Answer table” provided at the end of **this** section. This section is worth 15 marks.

1. Which one of the following is a redox reaction?

i) Zn + 4HNO3 🡪 Zn(NO3)2 + 2NO2 + 2H2O

ii) Ba2+ + SO42- 🡪 BaSO4

iii) CaCO3 🡪 CaO + CO2

iv) 2Na+ + 2H2O 🡪 2NaOH + H2

v) Fe + Cu2+ 🡪 Cu + Fe2+

a) i and ii only b) i, iv and vi only c) ii, iii, iv only d) ii and v only

2. Which of the following would not be an oxidation product of hydrogen sulphide (H2S)?

a) SO2 b) S c) S2- d) H2SO4

3. Which of the following species contains a group V element in a different oxidation state?

a) N2O5 b) POBr3 c) HPO42- d) KAsO4

4. Which of the following can not act as an oxidising agent?

a) Cl2 b) Cl- c) Fe2+ d) SO2

5. Which of the following can not be a reduction product of nitric acid?

a) N2O5 b) N2O c) N2 d) NO

6. The reaction occurring at the cathode of a lead-acid accumulator (car battery) is

a) PbO2 + 4H+ + 4e- 🡪 Pb + 2H2O b) Pb 🡪 Pb2+ + 2e-

c) Pb + SO42- 🡪 PbSO4+ + 2e- d) PbO2 + 2H2O + 4e- 🡪 Pb + 4OH-

7. Tin can displace lead from a solution of lead (II) nitrate. Therefore,

a) only lead can displace hydrogen from acids but tin cannot.

b) only tin will displace hydrogen from acids but lead cannot.

c) both metals will displace hydrogen from acids.

d) none of the above predictions can be made without further information.

8. A piece of zinc metal continues to burn in a jar of chlorine gas to give ZnCl2, heat and light. Which of the following statements is correct?

a) Chlorine is the reducing agent.

b) Zinc metal loses electrons and is reduced.

c) Zinc metal loses electrons and is oxidized.

d) Chlorine loses electrons and is oxidized

9. The formula for selenic acid is H6SeO6. The oxidation numbers of each of the elements are

a) H = +1; Se = + 6; O = -2 b) H = + 6; Se = 0; O = -6

c) H = 0; Se = + 6; O = -6 d) H = -1; Se = -6; O = +2

10. When potassium dichromate (K2Cr2O7) acts as an oxidising agent for iron (II) sulfate, the oxidation number of chromium changes to

a) +3 b) +6 c) +2 d) does not change

11. A cell is constructed from an Ag+/Ag half cell and a Cu2+/Cu half cell. Which of the following represents the overall reaction of the cell?

a) Ag+ + Cu 🡪 Ag + Cu2+ b) Cu2+ + Ag🡪 Cu + Ag+

c) Ag+ + 2Cu 🡪 Ag + 2Cu+ d) 2Ag+ + Cu 🡪 2Ag + Cu2+

12. The reaction between acidified potassium dichromate and potassium bromide solutions is best represented by which one of the following?

a) 2Cr2O72- + 6Br- + 14H+ 🡪 2Cr3+ + 3Br2 + 7H2O

b) Cr2O72- + 6Br- + 14H+ 🡪 2Cr3+ + 3Br2 + 7H2O

c) Cr2O72- + 2Br- + 14H+ 🡪 2Cr3+ + Br2 + 7H2O

d) 2Cr3+ + 3Br2 + 7H2O 🡪 Cr2O72- + 6Br- + 14H+

13. Which of the following reactions will not occur spontaneously?

a) Ag+ + Fe2+ 🡪 Ag + Fe3+ b) Zn + 2H+ 🡪 Zn2+ + H2

c) Li+ + Pb 🡪 Li + Pb2+ d) Pb2+ + Mg 🡪 Mg2+ + Pb

14. The function of the salt bridge is to

a) complete the circuit by allowing the ions to move between the two half-cells.

b) complete the circuit by allowing electrons to move between the two half-cells.

c) complete the circuit by allowing a current to flow from the anode to the cathode.

d) complete the circuit by allowing a current to flow from the cathode to the anode.

15. In a zinc/copper electrochemical cell, which of the following solutions can be used as the solution in a salt bridge?

i) 1.0 mol L-1 NaCl ii) 1.0 mol L-1 KNO3 iii) 1 mol L-1 Na2SO4

a) I only b) ii only c) iii only d) All three

**Enter the correct alternative for the answer you have selected in the table below:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Qn.1 | Qn. 2 | Qn.3 | Qn.4 | Qn.5 | Qn.6 | Qn.7 | Qn.8 |
| Qn.9 | Qn.10 | Qn.11 | Qn.12 | Qn.13 | Qn.14 | Qn. 15 | ------------ |

**Section 2. Short Answer questions.**

**Instructions:** Answer **all** the 6 questions in the space provided. This section is worth 30 marks.

1. Complete and balance the following equations. (4)

a) Cr2O72-(aq) + Cl-(aq) 🡪 Cr3+(aq) + Cl2(g)

b) CN-(aq) + MnO4-(aq) 🡪 CNO-(aq) + MnO2(s) in basic solution.

2. Draw a diagram of an electrochemical using nickel and copper using appropriate electrolytes.

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|  |

a) Label the anode and the cathode. (1)

b) Name an electrolyte for the anode half cell and one for the cathode half cell.(1)

c) Suggest a suitable salt solution for the salt bridge.(1)

d) Write the equation and the half cell value for the reaction that occurs at the cathode and the anode. Indicate the half cell emf’s and the overall reaction and the cell emf. (2)

e) List the changes you will observe in each cell as the reaction proceeds. (1)

3. Using the information from the Standard Reduction Potential Table, determine whether the following reactions are spontaneous under standard conditions. Show how you worked this out. (5)

a) Cu(s) + 2H+(aq) 🡪 Cu2+(aq) + H2(g)

b) Cl2(g) + 2I-(aq) 🡪 2Cl-(aq) + I2(s)

4. a) Arrange the following species in order of increasing strength as oxidising agents: (2)

Cr2O72-(aq), H2O2(aq) Cu2+(aq) Cl2(aq) O2(g)

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b) Which of the following processes are spontaneous under standard conditions? (3)

i) H2S(aq) + Cl2(aq) 🡪 S(s) + 2Cl-(aq) + 2H+(aq) -----------------------------------------------

ii) 5H2O2(l) + Cl2(aq) 🡪 4H2O(l) + 2H+(aq) + 2ClO3-(aq) -------------------------------------

iii) 2Cl-(aq) + Cu2+(aq) 🡪 Cu(s) + Cl2(g) ---------------------------------------------------------

iv) 10NO3-(aq) + 3I2(s) + 4H+(aq) 🡪 10NO(g) + 6IO3-(aq) + 2H2O(l)------------------------

5. a) What reactions take place during the discharge of a nickel-cadmium rechargeable cell which uses cadmium for the anode and NiO2 for the cathode? (2)

b) Given the following half-cell potentials, calculate the standard emf of the cell during discharge. (2)

Cd(OH)2(s) + 2e- 🡪 Cd(s) + 2OH-(aq) Eo = -0.76 V

NiO2(s) + 2H2O(l) + 2e- 🡪 Ni(OH)2(s) + 2OH-(aq) Eo = +0.49 V

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6. a) In a redox reaction an indicator may be needed for some reactions and not needed for some other reactions. Explain why using appropriate examples. (3)

b) When using potassium permanganate as an oxidising agent, only sulfuric acid is used and not hydrochloric acid. When potassium dichromate is used as an oxidising agent however, either hydrochloric acid for sulfuric acid could be used. Explain why. (3)

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**Section 3: Extended Answer Questions:** There are three calculations to be attempted. This section is worth 15 marks.

**Instruction**: Show all working in the space provided after each question. Attempt all questions.

1. A 12 Volt battery contains 410 g of lead in its anode plates and molar equivalent amounts of lead peroxide (PbO2) in its cathode plates.

a) How many coulombs of electrical charge can it deliver without being discharged? (3)

b) For how many hours could the battery deliver a steady current of 1.0 A assuming the current remains constant? (2)

2. Explain the effect caused if an iron gutter were nailed to a house using aluminium nails. (4)

3. 4.00 g of an impure iron wire was dissolved in excess dilute sulfuric acid and is converted to iron (II) sulfate (FeSO4) solution. This solution was made up to 500.0 mL in a volumetric flask. 25.0 mL of this solution required 20.0 mL of a 0.0300 mol L-1 potassium permanganate solution for complete oxidation. Calculate the percentage of iron in the iron wire. (6)

**End of test**

**ANSWERS:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Qn.1 *b* | Qn. 2 *c* | Qn.3 *d* | Qn.4 *b* | Qn.5 *a* | Qn.6 *a* | Qn.7 *d* | Qn.8 *c* |
| Qn.9 *a* | Qn.10 *a* | Qn.11 *d* | Qn.12 *b* | Qn.13 *c* | Qn.14 *a* | Qn. 15 *d* | ------------ |

**Section 2. Short Answer questions.**

**Instructions:** Answer **all** the 6 questions in the space provided. This section is worth 30 marks.

1. Complete and balance the following equations. (4)

a) Cr2O72-(aq) + Cl-(aq) 🡪 Cr3+(aq) + Cl2(g)

*Reduction: Cr2O72-(aq) + 14H+(aq) + 6e- 🡪 2Cr3+(aq) + 7H2O(l)*

*Oxidation: 2Cl-(aq) 🡪 Cl2(g) + 2e-*

*Redox: Cr2O72-(aq) + 6Cl-(aq) + 14H+(aq) 🡪 2Cr3+(aq) + 7H2O(l) + 3Cl2(g)*

b) CN-(aq) + MnO4-(aq) 🡪 CNO-(aq) + MnO2(s) in basic solution.

*Reduction: MnO4-(aq) + 4H+(aq) + 3e- 🡪 MnO2(s) + 2H2O(l)*

*Oxidation: CN-(aq) + H2O(l) 🡪 CNO-(aq) + 2H+ + 2e-*

*Reduction in basic solution: MnO4-(aq) + 2H2O(l) + 3e- 🡪 MnO2(s) + 4OH-(aq)*

*Oxidation in basic solution: 3CN-(aq) + 6OH-(aq) 🡪 3CNO-(aq) + 3H2O(l) + 6e-*

*Balanced equation: 3CN-(aq) + H2O(l) + 2MnO4-(aq) 🡪 3CNO-(aq) + 2MnO2(s) + 2OH-(aq)*

2. Draw a diagram of an electrochemical using nickel and copper using appropriate electrolytes.

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a) Label the anode and the cathode. (1)

*Nickel is anode and copper is the cathode.*

b) Name an electrolyte for the anode half cell and one for the cathode half cell.(1)

*Anode half cell: Nickel sulphate (NiSO4) and the cathode half cell: copper sulphate (CuSO4)*

c) Suggest a suitable salt solution for the salt bridge.(1)

*Potassium nitrate or sodium nitrate.*

d) Write the equation and the half cell value for the reaction that occurs at the cathode and the anode. Indicate the half cell emf’s and the overall reaction and the cell emf. (2)

*Cathode: Reduction: Cu2+ + 2e- 🡪 Cu(s) +0.34 V*

*Anode: Oxidation: Ni(s) 🡪 Ni2+ + 2e- +0.26*

*Overall reaction: Cu2+(aq) + Ni(s) 🡪 Cu(s) + Ni2+ (aq) +0.60 V*

e) List the changes you will observe in each cell as the reaction proceeds. (1)

*i) The blue colour fades in the cathode half cell. ii) Nickel metal gets corroded. ii) A brown powder is being deposited on the copper electrode. iv) Both cells get warmer.*

3. Using the information from the Standard Reduction Potential Table, determine whether the following reactions are spontaneous under standard conditions. Show how you worked this out. (5)

a) Cu(s) + 2H+(aq) 🡪 Cu2+(aq) + H2(g)

*Cu(s) 🡪 Cu2+(aq) + 2e- -0.34 V*

*2H+(aq) + 2e- 🡪 H2(g) 0 V*

*Cu(s) + 2H+(aq) 🡪 Cu2+(aq) + H2(g) -0.34 V*

*The standard emf is negative and therefore, the reaction will not be spontaneous.*

b) Cl2(g) + 2I-(aq) 🡪 2Cl-(aq) + I2(s)

*Cl2(g) + 2e- 🡪 2Cl-(aq) 1.36 V*

*2I- (aq) 🡪 I2(s) + 2e- -0.54 V*

*Cl2(g) + 2I-(aq) 🡪 2Cl-(aq) + I2(s) 0.82 V*

*The standard emf is positive and therefore, the reaction will be spontaneous.*

4. a) Arrange the following species in order of increasing strength as oxidising agents: (2)

Cr2O72-(aq), H2O2(aq) Cu2+(aq) Cl2(aq) O2(g)

*Cu2+(aq) , O2(g), Cr2O72-(aq), Cl2(aq), H2O2(aq)*

b) Which of the following processes are spontaneous under standard conditions? (3)

i) H2S(aq) + Cl2(aq) 🡪 S(s) + 2Cl-(aq) + 2H+(aq)

ii) 5H2O2(l) + Cl2(aq) 🡪 4H2O(l) + 2H+(aq) + 2ClO3-(aq)

iii) 2Cl-(aq) + Cu2+(aq) 🡪 Cu(s) + Cl2(g)

iv) 10NO3-(aq) + 3I2(s) + 4H+(aq) 🡪 10NO(g) + 6IO3-(aq) + 2H2O(l)

*i) Net Eo is positive, the reaction is spontaneous.*

*ii) Net Eo is positive, the reaction is spontaneous.*

*iii) Net Eo is negative, the reaction is not spontaneous.*

*iv) Net Eo is negative, the reaction is not spontaneous.*

5. a) What reactions take place during the discharge of a nickel-cadmium rechargeable cell which uses cadmium for the anode and NiO2 for the cathode? (2)

*Reaction: Cd(s) + NiO2(s) +2H2O(l) 🡪 Cd(OH)2(s) + Ni(OH)2(s)*

*In charging, the reverse reaction occurs.*

b) Given the following half-cell potentials, calculate the standard emf of the cell during discharge. (2)

Cd(OH)2(s) + 2e- 🡪 Cd(s) + 2OH-(aq) Eo = -0.76 V

NiO2(s) + 2H2O(l) + 2e- 🡪 Ni(OH)2(s) + 2OH-(aq) Eo = +0.49 V

*Eo = 1.25 V*

6. a) In a redox reaction an indicator may be needed for some reactions and not needed for some other reactions. Explain why using appropriate examples. (3)

*In a volumetric analysis titration with potassium permanganate solution, the colour changes from deep purple to pale pink at the equivalence point. Therefore, potassium permanganate is its own indicator.*

*In the volumetric analysis between hydrogen peroxide and oxalic acid, an indicator is needed because both the solutions are colourless and no colour change will appear to indicate the equivalence point.*

b) When using potassium permanganate as an oxidising agent, only sulfuric acid is used and not hydrochloric acid. When potassium dichromate is used as an oxidising agent however, either hydrochloric acid for sulfuric acid could be used. Explain why. (3)

*The permanganate ion, MnO4- will react with Cl- ion oxidising it to chlorine instead of the species it is intended to oxidize. Cr2O7- will not oxidize Cl- ion and hence is readily available to oxidize the intended species,*

**Section 3: Extended Answer Questions:** There are three calculations to be attempted. This section is worth 15 marks.

**Instruction**: Show all working in the space provided after each question. Attempt all questions.

1. A 12 Volt battery contains 410 g of lead in its anode plates and molar equivalent amounts of lead peroxide (PbO2) in its cathode plates.

a) How many coulombs of electrical charge can it deliver without being discharged? (3)

*Pb(s) 🡪 Pb2+ + 2e-*

*n (Pb) = (410 ÷ 207.2) = 1.98 mol; n(e-) = 2 X 1.98 = 3.96 mol*

*Since, n (e-) = Q ÷ 96490,*

*Q (Quantity of charge) = 3.96 X 96490 =* ***3.82 X 105 Coulombs***.

b) For how many hours could the battery deliver a steady current of 1.0 A assuming the current remains constant? (2)

*Q = I X t, and hence, t = Q ÷ I*

*Therefore, t = (3.82 X 105 ÷ 1.0) = 3.82 X 105 seconds, or (3.82 X 105 ÷ 3600) =* ***106 hours****.*

2. Explain the effect caused if an iron gutter were nailed to a house using aluminium nails. (4)

*A galvanic cell can be formed at the point of contact between the two metals. The metal that is most easily oxidized will act as the anode, while the other metal acts as the cathode. By comparing the standard reduction potentials of Al and Fe, we can see that aluminium will be the anode as it has a lower reduction potential than iron.*

*Al3+(aq) + 3e- 🡪 Al(s) -1.66 V*

*Fe2+(aq) + 2e- 🡪 Fe(s) -0.44 V*

*The gutter will thus be protected against corrosion in the vicinity of the nail, because the iron serves as the cathode. However, the nail would quickly corrode, and the gutter will fall away from where it should be.*

3. 4.00 g of an impure iron wire was dissolved in excess dilute sulfuric acid and is converted to iron (II) sulfate (FeSO4) solution. This solution was made up to 500.0 mL in a volumetric flask. 25.0 mL of this solution required 20.0 mL of a 0.0300 mol L-1 potassium permanganate solution for complete oxidation. Calculate the percentage of iron in the iron wire. (6)

*m (impure iron) = 4.00 g. This is dissolved in H2SO4 and forms FeSO4.*

*Volume made up = 500.0 mL; Volume used for titration: 25.0 mL*

*The reaction equation: MnO4-(aq) + 5Fe2+(aq) + 8H+(aq) 🡪 Mn2+(aq) + 5Fe3+ + 4H2O(l)*

*n (MnO4-) used in each titration = 0.030 mol L-1 X 0.020 L = 0.0006 mol*

*Therefore, n (Fe2+) = 5 X 0.0006 = 0.0030 mol in 0.0250 L of the FeSO4 solution.*

*Therefore, n (Fe2+) in the 0.500 L solution made up initially in the volumetric flask,*

*= [(0.0030 X 0.5) ÷ 0.025] = 0.06 mol*

*Therefore, n (Fe) = n (Fe2+) = 0.06 mol*

*Therefore, m (Fe) = n X M = 0.06 X 55.85 = 3.351 g*

*Therefore, % Fe in the wire = [(3.351 ÷ 4.00) X 100] =* ***83.8%.***

**End of test**

*TEACHER DEVELOPMENT CENTRE CHEMISTRY*

**3BCHE CHEMISTRY**

**TEST 6. REDOX AND ELECTROCHEMICAL CELLS – MARKS 60**

**Areas covered in this test:** Common oxidising and reducing agents; assigning oxidation numbers; balancing redox equations; performing calculations on redox titrations; redox volumetric analysis procedures; constructing electrochemical cells; calculating the cell potentials; commercial cells.

**Instructions to students**: This test consists of three sections. Section 1 consists of fifteen (15) multiple choice questions. Section 2 consists of 6 short-answer questions. Section 3 consists of 3 calculations. Attempt *all* the questions.

**Section 1. Multiple Choice questions**: Mark your selected answer for each question in the “Answer table” provided at the end of **this** section. This section is worth 15 marks.

1. Which one of the following is a redox reaction?

i) Zn + 4HNO3 🡪 Zn(NO3)2 + 2NO2 + 2H2O

ii) Ba2+ + SO42- 🡪 BaSO4

iii) CaCO3 🡪 CaO + CO2

iv) 2Na+ + 2H2O 🡪 2NaOH + H2

v) Fe + Cu2+ 🡪 Cu + Fe2+

a) i and ii only b) i, iv and vi only c) ii, iii, iv only d) ii and v only

2. Which of the following would not be an oxidation product of hydrogen sulphide (H2S)?

a) SO2 b) S c) S2- d) H2SO4

3. Which of the following species contains a group V element in a different oxidation state?

a) N2O5 b) POBr3 c) HPO42- d) KAsO4

4. Which of the following can not act as an oxidising agent?

a) Cl2 b) Cl- c) Fe2+ d) SO2

5. Which of the following can not be a reduction product of nitric acid?

a) N2O5 b) N2O c) N2 d) NO

6. The reaction occurring at the cathode of a lead-acid accumulator (car battery) is

a) PbO2 + 4H+ + 4e- 🡪 Pb + 2H2O b) Pb 🡪 Pb2+ + 2e-

c) Pb + SO42- 🡪 PbSO4+ + 2e- d) PbO2 + 2H2O + 4e- 🡪 Pb + 4OH-

7. Tin can displace lead from a solution of lead (II) nitrate. Therefore,

a) only lead can displace hydrogen from acids but tin cannot.

b) only tin will displace hydrogen from acids but lead cannot.

c) both metals will displace hydrogen from acids.

d) none of the above predictions can be made without further information.

8. A piece of zinc metal continues to burn in a jar of chlorine gas to give ZnCl2, heat and light. Which of the following statements is correct?

a) Chlorine is the reducing agent.

b) Zinc metal loses electrons and is reduced.

c) Zinc metal loses electrons and is oxidized.

d) Chlorine loses electrons and is oxidized

9. The formula for selenic acid is H6SeO6. The oxidation numbers of each of the elements are

a) H = +1; Se = + 6; O = -2 b) H = + 6; Se = 0; O = -6

c) H = 0; Se = + 6; O = -6 d) H = -1; Se = -6; O = +2

10. When potassium dichromate (K2Cr2O7) acts as an oxidising agent for iron (II) sulfate, the oxidation number of chromium changes to

a) +3 b) +6 c) +2 d) does not change

11. A cell is constructed from an Ag+/Ag half cell and a Cu2+/Cu half cell. Which of the following represents the overall reaction of the cell?

a) Ag+ + Cu 🡪 Ag + Cu2+ b) Cu2+ + Ag🡪 Cu + Ag+

c) Ag+ + 2Cu 🡪 Ag + 2Cu+ d) 2Ag+ + Cu 🡪 2Ag + Cu2+

12. The reaction between acidified potassium dichromate and potassium bromide solutions is best represented by which one of the following?

a) 2Cr2O72- + 6Br- + 14H+ 🡪 2Cr3+ + 3Br2 + 7H2O

b) Cr2O72- + 6Br- + 14H+ 🡪 2Cr3+ + 3Br2 + 7H2O

c) Cr2O72- + 2Br- + 14H+ 🡪 2Cr3+ + Br2 + 7H2O

d) 2Cr3+ + 3Br2 + 7H2O 🡪 Cr2O72- + 6Br- + 14H+

13. Which of the following reactions will not occur spontaneously?

a) Ag+ + Fe2+ 🡪 Ag + Fe3+ b) Zn + 2H+ 🡪 Zn2+ + H2

c) Li+ + Pb 🡪 Li + Pb2+ d) Pb2+ + Mg 🡪 Mg2+ + Pb

14. The function of the salt bridge is to

a) complete the circuit by allowing the ions to move between the two half-cells.

b) complete the circuit by allowing electrons to move between the two half-cells.

c) complete the circuit by allowing a current to flow from the anode to the cathode.

d) complete the circuit by allowing a current to flow from the cathode to the anode.

15. In a zinc/copper electrochemical cell, which of the following solutions can be used as the solution in a salt bridge?

i) 1.0 mol L-1 NaCl ii) 1.0 mol L-1 KNO3 iii) 1 mol L-1 Na2SO4

a) I only b) ii only c) iii only d) All three

**Enter the correct alternative for the answer you have selected in the table below:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Qn.1 | Qn. 2 | Qn.3 | Qn.4 | Qn.5 | Qn.6 | Qn.7 | Qn.8 |
| Qn.9 | Qn.10 | Qn.11 | Qn.12 | Qn.13 | Qn.14 | Qn. 15 | ------------ |

**Section 2. Short Answer questions.**

**Instructions:** Answer **all** the 6 questions in the space provided. This section is worth 30 marks.

1. Complete and balance the following equations. (4)

a) Cr2O72-(aq) + Cl-(aq) 🡪 Cr3+(aq) + Cl2(g)

b) CN-(aq) + MnO4-(aq) 🡪 CNO-(aq) + MnO2(s) in basic solution.

2. Draw a diagram of an electrochemical using nickel and copper using appropriate electrolytes.

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|  |

a) Label the anode and the cathode. (1)

b) Name an electrolyte for the anode half cell and one for the cathode half cell.(1)

c) Suggest a suitable salt solution for the salt bridge.(1)

d) Write the equation and the half cell value for the reaction that occurs at the cathode and the anode. Indicate the half cell emf’s and the overall reaction and the cell emf. (2)

e) List the changes you will observe in each cell as the reaction proceeds. (1)

3. Using the information from the Standard Reduction Potential Table, determine whether the following reactions are spontaneous under standard conditions. Show how you worked this out. (5)

a) Cu(s) + 2H+(aq) 🡪 Cu2+(aq) + H2(g)

b) Cl2(g) + 2I-(aq) 🡪 2Cl-(aq) + I2(s)

4. a) Arrange the following species in order of increasing strength as oxidising agents: (2)

Cr2O72-(aq), H2O2(aq) Cu2+(aq) Cl2(aq) O2(g)

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b) Which of the following processes are spontaneous under standard conditions? (3)

i) H2S(aq) + Cl2(aq) 🡪 S(s) + 2Cl-(aq) + 2H+(aq) -----------------------------------------------

ii) 5H2O2(l) + Cl2(aq) 🡪 4H2O(l) + 2H+(aq) + 2ClO3-(aq) -------------------------------------

iii) 2Cl-(aq) + Cu2+(aq) 🡪 Cu(s) + Cl2(g) ---------------------------------------------------------

iv) 10NO3-(aq) + 3I2(s) + 4H+(aq) 🡪 10NO(g) + 6IO3-(aq) + 2H2O(l)------------------------

. a) What reactions take place during the discharge of a nickel-cadmium rechargeable cell which uses cadmium for the anode and NiO2 for the cathode? (2)

b) Given the following half-cell potentials, calculate the standard emf of the cell during discharge. (2)

Cd(OH)2(s) + 2e- 🡪 Cd(s) + 2OH-(aq) Eo = -0.76 V

NiO2(s) + 2H2O(l) + 2e- 🡪 Ni(OH)2(s) + 2OH-(aq) Eo = +0.49 V

*-------------------------------------------------------------------------------*

6. a) In a redox reaction an indicator may be needed for some reactions and not needed for some other reactions. Explain why using appropriate examples. (3)

b) When using potassium permanganate as an oxidising agent, only sulfuric acid is used and not hydrochloric acid. When potassium dichromate is used as an oxidising agent however, either hydrochloric acid for sulfuric acid could be used. Explain why. (3)

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**Section 3: Extended Answer Questions:** There are three calculations to be attempted. This section is worth 15 marks.

**Instruction**: Show all working in the space provided after each question. Attempt all questions.

1. A 12 Volt battery contains 410 g of lead in its anode plates and molar equivalent amounts of lead peroxide (PbO2) in its cathode plates.

a) How many coulombs of electrical charge can it deliver without being discharged? (3)

b) For how many hours could the battery deliver a steady current of 1.0 A assuming the current remains constant? (2)

2. Explain the effect caused if an iron gutter were nailed to a house using aluminium nails. (4)

3. 4.00 g of an impure iron wire was dissolved in excess dilute sulfuric acid and is converted to iron (II) sulfate (FeSO4) solution. This solution was made up to 500.0 mL in a volumetric flask. 25.0 mL of this solution required 20.0 mL of a 0.0300 mol L-1 potassium permanganate solution for complete oxidation. Calculate the percentage of iron in the iron wire. (6)

**End of test**