**IB Chemistry – SL**

**Topic 9 Questions**

**1.** Which statement is correct?

A. Oxidation involves loss of electrons and a decrease in oxidation state.

B. Oxidation involves gain of electrons and an increase in oxidation state.

C. Reduction involves loss of electrons and an increase in oxidation state.

D. Reduction involves gain of electrons and a decrease in oxidation state.

(Total 1 mark)

**2.** What occurs during the operation of a voltaic cell based on the following reaction?

Ni(s) + Pb2+(aq) → Ni2+(aq) + Pb(s)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **External circuit** | **Ion movement in solution** |  |
|  | electrons move from Ni to Pb | Pb2+(aq) move away from Pb(s) | A. |
|  | electrons move from Ni to Pb | Pb2+(aq) move toward Pb(s) | B. |
|  | electrons move from Pb to Ni | Ni2+(aq) move away from Ni(s) | C. |
|  | electrons move from Pb to Ni | Ni2+(aq) move toward Ni(s) | D. |

(Total 1 mark)

**3.** The oxidation number of chromium is the same in all the following compounds **except**

A. Cr(OH)3

B. Cr2O3

C. Cr2(SO4)3

D. CrO3

(Total 1 mark)

**4.** Magnesium is a more reactive metal than copper. Which is the strongest oxidizing agent?

A. Mg

B. Mg2+

C. Cu

D. Cu2+

(Total 1 mark)

**5.** Which processes occur during the electrolysis of molten sodium chloride?

I. Sodium and chloride ions move through the electrolyte.

II. Electrons move through the external circuit.

III. Oxidation takes place at the positive electrode (anode).

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

**6.** What happens to the Cr3+(aq) ion when it is converted to CrO42–(aq)?

A. Its oxidation number decreases and it undergoes reduction.

B. Its oxidation number decreases and it undergoes oxidation.

C. Its oxidation number increases and it undergoes reduction.

D. Its oxidation number increases and it undergoes oxidation.

(Total 1 mark)

**7.** The following reactions are spontaneous as written.

Fe(s) + Cd2+(aq) → Fe2+(aq) + Cd(s)

Cd(s) + Sn2+(aq) → Cd2+(aq) + Sn(s)

Sn(s) + Pb2+(aq) → Sn2+(aq) + Pb(s)

Which of the following pairs will react spontaneously?

I. Sn(s) + Fe2+(aq)

II. Cd(s) + Pb2+(aq)

III. Fe(s) + Pb2+(aq)

A. I only

B. II only

C. III only

D. II and III only

(Total 1 mark)

**8.** What species are produced at the positive and negative electrodes during the electrolysis of molten sodium chloride?

|  |  |  |
| --- | --- | --- |
| **Positive electrode** | **Negative electrode** |  |
| Na+(l) | Cl2(g) | A. |
| Cl–(l) | Na+(l) | B. |
| Na(l) | Cl2(g) | C. |
| Cl2(g) | Na(l) | D. |

(Total 1 mark)

**9.** Consider the following reaction.

H2SO3(aq) + Sn4+(aq) + H2O(l) → Sn2+(aq) + HSO4–(aq) + 3H+(aq)

Which statement is correct?

A. H2SO3 is the reducing agent because it undergoes reduction.

B. H2SO3 is the reducing agent because it undergoes oxidation.

C. Sn4+ is the oxidizing agent because it undergoes oxidation.

D. Sn4+ is the reducing agent because it undergoes oxidation.

(Total 1 mark)

**10.** In which change does oxidation occur?

A. CH3CHO → CH3CH2OH

B. CrO42–→ Cr2O72–

C. SO42–→ SO32–

D. NO2– → NO3–

(Total 1 mark)

**11.** What happens at the positive electrode in a voltaic cell and in an electrolytic cell?

|  |  |  |
| --- | --- | --- |
| **Voltaic cell** | **Electrolytic cell** |  |
| Oxidation | Reduction | A. |
| Reduction | Oxidation | B. |
| Oxidation | Oxidation | C. |
| Reduction | Reduction | D. |

(Total 1 mark)

**12.** What are the oxidation numbers of the elements in sulfuric acid, H2SO4?

|  |  |  |  |
| --- | --- | --- | --- |
| **Hydrogen** | **Sulfur** | **Oxygen** |  |
| +1 | +6 | –2 | A. |
| +1 | +4 | –2 | B. |
| +2 | +1 | +4 | C. |
| +2 | +6 | –8 | D. |

(Total 1 mark)

**13.** A voltaic cell is made from copper and zinc half-cells. The equation for the reaction occurring in the cell is

Zn(s) + Cu2+(aq) → Zn2+(aq) + Cu(s)

Which statement is correct when the cell produces electricity?

A. Electrons are lost from zinc atoms.

B. The mass of the copper electrode decreases.

C. Electrons flow from the copper half-cell to the zinc half-cell.

D. Negative ions flow through the salt bridge from the zinc half-cell to the copper half-cell.

(Total 1 mark)

**14.** What happens when molten sodium chloride is electrolyzed in an electrolytic cell?

A. Chlorine is produced at the positive electrode.

B. Sodium ions lose electrons at the negative electrode.

C. Electrons flow through the liquid from the negative electrode to the positive electrode.

D. Oxidation occurs at the negative electrode and reduction at the positive electrode.

(Total 1 mark)

**15.** Which equations represent reactions that occur at room temperature?

I. 2Br–(aq) + Cl2(aq)  2Cl–(aq) + Br2(aq)

II. 2Br–(aq) + I2(aq)  2I–(aq) + Br2(aq)

III. 2I–(aq) + Cl2(aq)  2Cl–(aq) + I2(aq)

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

**16.** Which equation represents a redox reaction?

A. KOH(aq) + HCl(aq)  KCl(aq) + H2O(l)

B. Mg(s) + 2HCl(aq)  MgCl2(aq) + H2(g)

C. CuO(s) + 2HCl(aq)  CuCl2(aq) + H2O(l)

D. ZnCO3(s) + 2HCl(aq)  ZnCl2(aq) + CO2(g) + H2O(l)

(Total 1 mark)

**17.** The following information is given about reactions involving the metals X, Y and Z and solutions of their sulfates.

X(s) + YSO4(aq)  no reaction

Z(s) + YSO4(aq)  Y(s) + ZSO4(aq)

When the metals are listed in decreasing order of reactivity (most reactive first), what is the correct order?

A. Z  Y  X

B. X  Y  Z

C. Y  X  Z

D. Y  Z  X

(Total 1 mark)

**18.** What are the oxidation numbers of the elements in the compound phosphoric acid, H3PO4?

|  |  |  |  |
| --- | --- | --- | --- |
| Hydrogen | Phosphorus | Oxygen |  |
| +1 | +1 | –2 | A. |
| +1 | +5 | –2 | B. |
| +3 | +1 | –4 | C. |
| +3 | +5 | –8 | D. |

(Total 1 mark)

**19.** A voltaic cell is made from magnesium and iron half-cells. Magnesium is a more reactive metal than iron. Which statement is correct when the cell produces electricity?

A. Electrons are lost from magnesium atoms.

B. The concentration of Fe2+ ions increases.

C. Electrons flow from the iron half-cell to the magnesium half-cell.

D. Negative ions flow through the salt bridge from the magnesium half-cell to the iron half-cell.

(Total 1 mark)

**20.** Which are examples of reduction?

I. Fe3+ becomes Fe2+

II. Cl– becomes Cl2

III. CrO3 becomes Cr3+

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

**21.** Which statement is correct for the electrolysis of a molten salt?

A. Positive ions move toward the positive electrode.

B. A gas is produced at the negative electrode.

C. Only electrons move in the electrolyte.

D. Both positive and negative ions move toward electrodes.

(Total 1 mark)

**22.** Which statement about the following reaction is correct?

2Br–(aq) + Cl2(aq)  Br2(aq) + 2Cl–(aq)

A. Br–(aq) is reduced and gains electrons.

B. Cl2(aq) is reduced and loses electrons.

C. Br–(aq) is oxidized and loses electrons.

D. Cl2(aq) is oxidized and gains electrons.

(Total 1 mark)

**23.** Consider the following spontaneous reactions.

Fe(s) + Cu2+(aq)  Fe2+(aq) + Cu(s)

Cu(s) + 2Ag+(aq)  Cu2+(aq) + 2Ag(s)

Zn(s) + Fe2+(aq)  Zn2+(aq) + Fe(s)

Which is the correct combination of strongest oxidizing agent and strongest reducing agent?

|  |  |  |
| --- | --- | --- |
| Strongest oxidizing agent | Strongest reducing agent |  |
| Ag(s) | Zn(s) | A. |
| Ag+(aq) | Zn(s) | B. |
| Zn2+(aq) | Ag(s) | C. |
| Zn(s) | Ag+(aq) | D. |

(Total 1 mark)

**24.** In which change does nitrogen undergo oxidation?

A. NO2  N2O4

B. NO3–  NO2

C. N2O5 NO3–

D. NH3  N2

(Total 1 mark)

**25.** Which statement is correct?

A. Spontaneous redox reactions produce electricity in an electrolytic cell.

B. Electricity is used to carry out a non-spontaneous redox reaction in a voltaic cell.

C. Oxidation takes place at the negative electrode in a voltaic cell and the positive electrode in an electrolytic cell.

D. Oxidation takes place at the negative electrode in a voltaic cell and reduction takes place at the positive electrode in an electrolytic cell.

(Total 1 mark)

**26.** The compound [Co(NH3)5Br]SO4 is isomeric with the compound [Co(NH3)5SO4]Br. What is the oxidation state of cobalt in these compounds?

|  |  |  |
| --- | --- | --- |
| [Co(NH3)5Br]SO4 | [Co(NH3)5SO4]Br |  |
| +3 | +3 | A. |
| +2 | +1 | B. |
| +3 | +2 | C. |
| +2 | +3 | D. |

(Total 1 mark)

**27.** What happens to vanadium during the reaction VO2+ (aq)  VO3- (aq)?

A. It undergoes oxidation and its oxidation number changes from +4 to +5.

B. It undergoes oxidation and its oxidation number changes from +2 to +4.

C. It undergoes reduction and its oxidation number changes from +2 to -1.

D. It undergoes reduction and its oxidation number changes from +4 to +2.

(Total 1 mark)

**28.** What occurs during the electrolysis of a molten salt?

A. Electricity is produced by a spontaneous redox reaction.

B. Electricity is used to cause a non-spontaneous redox reaction to occur.

C. Electrons flow through the molten salt.

D. Electrons are removed from both ions of the molten salt.

(Total 1 mark)

**29.** Which statement is correct about an oxidizing agent in a chemical reaction?

A. It reacts with oxygen.

B. It reacts with H+ ions.

C. It loses electrons.

D. It undergoes reduction.

(Total 1 mark)

**30.** Which formula represents an aldehyde?

A. CH3CH2CHO

B. CH3COCH3

C. CH3CH2COOH

D. CH3COOCH3

(Total 1 mark)

**31.** What is the reducing agent in this reaction?

Cu(s) + (aq) + 4H+(aq) → Cu2+(aq) + 2NO2(g) + 2H2O(l)

A. Cu(s)

B. (aq)

C. Cu2+(aq)

D. H+(aq)

(Total 1 mark)

**32.** A particular voltaic cell is made from magnesium and iron half-cells. The overall equation for the reaction occurring in the cell is

Mg(s) + Fe2+(aq) → Mg2+(aq) + Fe(s)

Which statement is correct when the cell produces electricity?

A. Magnesium atoms lose electrons.

B. The mass of the iron electrode decreases.

C. Electrons flow from the iron half-cell to the magnesium half-cell.

D. Negative ions flow through the salt bridge from the magnesium half-cell to the iron half-cell.

(Total 1 mark)

**33.** What process occurs at the cathode in a voltaic cell and at the anode in an electrolytic cell?

|  |  |  |
| --- | --- | --- |
| **Cathode of Voltaic Cell** | **Anode of Electrolytic Cell** |  |
| Oxidation | Reduction | A. |
| Oxidation | Oxidation | B. |
| Reduction | Oxidation | C. |
| Reduction | Reduction | D. |

(Total 1 mark)

**34.** Consider the following reaction:

H2SO3(aq) + Sn4+(aq) + H2O(l) → Sn2+(aq) + HSO4–(aq) + 3H+(aq)

Which statement is correct?

A. H2SO3 is the reducing agent because it undergoes reduction.

B. H2SO3 is the reducing agent because it undergoes oxidation.

C. Sn4+ is the oxidizing agent because it undergoes oxidation.

D. Sn4+ is the reducing agent because it undergoes oxidation.

(Total 1 mark)

**35.** Which processes occur during the electrolysis of molten sodium chloride?

I. Sodium and chloride ions move through the electrolyte.  
II. Electrons move through the external circuit.  
III. Oxidation takes place at the anode.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

**36.** Tin(II) ions can be oxidized to tin(IV) ions by acidified potassium permanganate(VII) solution according to the following unbalanced equation.

\_\_ Sn2+ + \_\_MnO4– + \_\_ H+ \_\_ Sn4+ + \_\_Mn2+ + \_\_ H2O

(a) Identify the oxidizing agent and the reducing agent.

Oxidizing agent .........................................................................................................

Reducing agent ..........................................................................................................

(1)

(b) Balance the equation above.

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(1)

(Total 2 marks)

**37.** Consider the following redox equation.

5Fe2+(aq) +MnO4–(aq) +8H+(aq) → 5Fe3+(aq) + Mn2+(aq) + 4H2O(l)

(i) Determine the oxidation numbers for Fe and Mn in the reactants and in the products.

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……………………………………………………………………………………………

(2)

(ii) Based on your answer to (i), deduce which substance is oxidized.

……………………………………………………………………………………………

(1)

(iii) The compounds CH3OH and CH2O contain carbon atoms with different oxidation numbers. Deduce the oxidation numbers and state the kind of chemical change needed to make CH2O from CH3OH.

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……………………………………………………………………………………………

……………………………………………………………………………………………

(3)

(Total 6 marks)

**38.** A part of the reactivity series of metals, in order of decreasing reactivity, is shown below.

magnesium  
zinc  
iron  
lead  
copper  
silver

If a piece of copper metal were placed in separate solutions of silver nitrate and zinc nitrate

(i) determine which solution would undergo reaction.

……………………………………………………………………………………………

(1)

(ii) identify the type of chemical change taking place in the copper and write the half-equation for this change.

……………………………………………………………………………………………

……………………………………………………………………………………………

(2)

(iii) state, giving a reason, what visible change would take place in the solutions.

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……………………………………………………………………………………………

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……………………………………………………………………………………………

(2)

(Total 5 marks)

**39.** (i) Solid sodium chloride does not conduct electricity but molten sodium chloride does. Explain this difference, and outline what happens in an electrolytic cell during the electrolysis of molten sodium chloride using carbon electrodes.

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(4)

(ii) State the products formed and give equations showing the reactions at each electrode.

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……………………………………………………………………………………………

(4)

(iii) State what practical use is made of this process.

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……………………………………………………………………………………………

(1)

(Total 9 marks)

**40.** Electrolysis can be used to obtain chlorine from molten sodium chloride. Write an equation for the reaction occurring at each electrode and describe the two different ways in which electricity is conducted when the cell is in operation.

(Total 4 marks)

**41.** Two reactions occurring in the manufacture of bromine from sea water are

I Cl2(g) + 2Br–(aq)  2Cl–(aq) + Br2(g)

II Br2(g) + SO2(g) + 2H2O(l)  2HBr(g) + H2SO4(g)

(i) Explain, by reference to electrons, why reaction I is referred to as a redox reaction.

(2)

(ii) State and explain whether SO2 is reduced or oxidized in reaction II by referring to the oxidation numbers of sulfur in this reaction.

(3)

(Total 5 marks)

**42.** In terms of electron transfer define:

(i) *oxidation*

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(1)

(ii) *oxidizing agent*

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(1)

(Total 2 marks)

**43.** Deduce the **change** in oxidation number of chromium in the below reaction. State with a reason whether the chromium has been oxidized or reduced.

CrO72 + 14H+ + 6Fe2+  2Cr3+ + 6Fe3+ + 7H2O

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(Total 2 marks)

**44.** (a) (i) Define *oxidizing agent* in terms of electron transfer.

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(1)

(ii) Deduce the **change** in oxidation number of chromium in the reaction below. State with a reason whether the chromium has been oxidized or reduced.

Cr2O7 2 + 14H+ + 6Fe2+  2Cr3+ + 7H2O

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(2)

(Total 3 marks)

**45.** Iron in food, in the form of Fe3+, reacts with ascorbic acid (vitamin C), C6H8O6, to form dehydroascorbic acid, C6H6O6.

(i) Write an ionic half-equation to show the conversion of ascorbic acid to dehydroascorbic acid in aqueous solution.

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.........................................................................................................................

(1)

(ii) In the other ionic half-equation Fe3+ is converted to Fe2+. Deduce the overall equation for the reaction between C6H8O6 and Fe3+.

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(1)

(Total 2 marks)

**46.** (i) Draw a diagram of apparatus that could be used to electrolyze molten potassium bromide. Label the diagram to show the polarity of each electrode and the product formed.

(3)

(ii) Describe the **two** different ways in which electricity is conducted in the apparatus.

(2)

(iii) Write an equation to show the formation of the product at each electrode.

(2)

(Total 7 marks)

**47.** Iodide ions, I–(aq), react with iodate ions, IO3–(aq), in an acidic solution to form molecular iodine and water.

(i) Determine the oxidation number of iodine in each iodine-containing species in the reaction.

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(2)

(ii) Identify, with a reason, the species that undergoes:

oxidation ....................................................................................................................

....................................................................................................................................

reduction ....................................................................................................................

....................................................................................................................................

(2)

(Total 4 marks)

**IB Chemistry – SL**

**Topic 9 Answers**

**1.** D

[1]

**2.** B

[1]

**3.** D

[1]

**4.** D

[1]

**5.** D

[1]

**6.** D

[1]

**7.** D

[1]

**8.** D

[1]

**9.** B

[1]

**10.** D

[1]

**11.** B

[1]

**12.** A

[1]

**13.** A

[1]

**14.** A

[1]

**15.** B

[1]

**16.** B

[1]

**17.** A

[1]

**18.** B

[1]

**19.** A

[1]

**20.** B

[1]

**21.** D

[1]

**22.** C

[1]

**23.** B

[1]

**24.** D

[1]

**25.** C

[1]

**26.** A

[1]

**27.** A

[1]

**28.** B

[1]

**29.** D

[1]

**30.** A

[1]

**31.** A

[1]

**32.** A

[1]

**33.** C

[1]

**34.** B

[1]

**35.** D

[1]

**36.** (a) *oxidizing agent:* (acidified) potassium permanganate(VII)/(H+) and Mn  
and *reducing agent*: Sn2+; 1

Both oxidizing agent and reducing agent required for **[1]**.

(b) 5Sn2+ + 2MnO4– + 16H+  5Sn4+ + 2Mn2+ + 8H2O; 1

[2]

**37.** (i) Fe reactant +2 AND Fe product +3 AND Mn product +2;  
Mn reactant +7; 2

Do not accept Roman numerals.

(ii) Fe2+/iron(ii) ions/ferrous ions; 1

Do not accept “iron”.

(iii) CH3OH oxidation state –2;  
CH2O oxidation state 0;  
(change is) oxidation/dehydrogenation; 3

[6]

**38.** (i) silver nitrate; 1

(ii) oxidation;  
Cu → Cu2+ + 2e; 2

(iii) (silver nitrate) solution turns blue/grey or black or silver solid forms;  
copper ions form/Cu2+ ions form/silver deposited; 2

[5]

**39.** (i) sodium chloride crystals consist of ions in a rigid lattice/ions can not   
move about;  
when melted the ions are free to move or ions move when a voltage  
is applied;  
in electrolysis positive sodium ions or Na+ ions move to the negative  
electrode or cathode; and negative chloride ions or Cl– move to the   
positive electrode or anode; 4

(ii) sodium formed at cathode or negative electrode;  
Na+ + e  Na;  
chlorine formed at anode or positive electrode; 4  
2Cl– → Cl2 + 2e;

1st and 3rd marks can be scored in (i).

(iii) manufacture of sodium and chlorine/one stated use of chlorine   
or sodium; 1

[9]

**40.** *at negative electrode (cathode)*

Na+ + e  Na;

*at positive electrode (anode)*

2Cl  Cl2 + 2e;

If both equations correct but electrodes incorrect or not stated, then deduct **[1]**.

electrons flow through the external circuit or wires;

ions gain/lose electrons at electrodes/ions move to electrodes. 4

[4]

**41.** (i) chlorine/Cl2 gains electrons and is reduced;

bromide (ions)/Br loses electrons and is oxidized; 2

Award **[1]** max if no mention of reduced and oxidized.

(ii) *S* *in* *SO*2

+4;

*S in H2SO4*

+6;

Award only **[1]** for 4 + and 6 + or 4 and 6.

SO2 oxidized because oxidation number (of sulfur) increases; 3

[5]

**42.** (i) loss of electrons; 1

(ii) (a species that) gains electrons (from another species)/causes electron loss; 1

[2]

**43.** changes by 3;

reduced because its oxidation number decreased / +6  +3 / 6+  3+ / it has gained

electrons;

[2]

**44.** (i) (a species that) gains electrons (from another species)/causes electron loss; 1

(ii) changes by 3;

reduced because its oxidation number decreased / +6  +3 / 6+  3+ /  
it has gained electrons; 2

[3]

**45.** (i) C6H8O6  C6H6O6 +2H+ + 2e; 1

(ii) C6H8O6 + 2Fe3+  C6H6O + 2H+ + 2Fe2+; 1

[2]

**46.** (i) (diagram showing)

container, liquid, electrodes and power supply;

bromine formed at + electrode;

potassium formed at  electrode; 3

Award **[1]** for both correct products shown at wrong electrodes, or if no polarity indicated.

(ii) electrons flow through connecting wires;  
ions move (through liquid) to electrodes (and lose/gain electrons); 2

(iii) K+ + e  K;

2Br  Br2 + 2e; 2

No need to indicate polarity of electrodes.

Accept e instead of e.

[7]

**47.** (i) I = 1 / 1

IO3 = +5 / 5+

I2 = 0 2

Award **[2]** for all three correct, **[1]** for any two correct,

Signs must be included

Do not accept Roman numerals

(ii) *oxidation*

I (to I2), increase in oxidation number/loss of electron(s);

*reduction*

IO3– (to I2), decrease in oxidation number/gain of electron(s); 2

[4]