88126101

International Baccalaureate®
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**CHEMISTRY**
**HIGHER LEVEL**
**PAPER 1**

Friday 9 November 2012 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is *[40 marks]*.

## The Periodic Table

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1<br>**H**<br>1.01 | | | | | | | | | | | | | | | | | 2<br>**He**<br>4.00 |
| 3<br>**Li**<br>6.94 | 4<br>**Be**<br>9.01 | | | | | | | | | | | 5<br>**B**<br>10.81 | 6<br>**C**<br>12.01 | 7<br>**N**<br>14.01 | 8<br>**O**<br>16.00 | 9<br>**F**<br>19.00 | 10<br>**Ne**<br>20.18 |
| 11<br>**Na**<br>22.99 | 12<br>**Mg**<br>24.31 | | | | | | | | | | | 13<br>**Al**<br>26.98 | 14<br>**Si**<br>28.09 | 15<br>**P**<br>30.97 | 16<br>**S**<br>32.06 | 17<br>**Cl**<br>35.45 | 18<br>**Ar**<br>39.95 |
| 19<br>**K**<br>39.10 | 20<br>**Ca**<br>40.08 | 21<br>**Sc**<br>44.96 | 22<br>**Ti**<br>47.90 | 23<br>**V**<br>50.94 | 24<br>**Cr**<br>52.00 | 25<br>**Mn**<br>54.94 | 26<br>**Fe**<br>55.85 | 27<br>**Co**<br>58.93 | 28<br>**Ni**<br>58.71 | 29<br>**Cu**<br>63.55 | 30<br>**Zn**<br>65.37 | 31<br>**Ga**<br>69.72 | 32<br>**Ge**<br>72.59 | 33<br>**As**<br>74.92 | 34<br>**Se**<br>78.96 | 35<br>**Br**<br>79.90 | 36<br>**Kr**<br>83.80 |
| 37<br>**Rb**<br>85.47 | 38<br>**Sr**<br>87.62 | 39<br>**Y**<br>88.91 | 40<br>**Zr**<br>91.22 | 41<br>**Nb**<br>92.91 | 42<br>**Mo**<br>95.94 | 43<br>**Tc**<br>98.91 | 44<br>**Ru**<br>101.07 | 45<br>**Rh**<br>102.91 | 46<br>**Pd**<br>106.42 | 47<br>**Ag**<br>107.87 | 48<br>**Cd**<br>112.40 | 49<br>**In**<br>114.82 | 50<br>**Sn**<br>118.69 | 51<br>**Sb**<br>121.75 | 52<br>**Te**<br>127.60 | 53<br>**I**<br>126.90 | 54<br>**Xe**<br>131.30 |
| 55<br>**Cs**<br>132.91 | 56<br>**Ba**<br>137.34 | 57 †<br>**La**<br>138.91 | 72<br>**Hf**<br>178.49 | 73<br>**Ta**<br>180.95 | 74<br>**W**<br>183.85 | 75<br>**Re**<br>186.21 | 76<br>**Os**<br>190.21 | 77<br>**Ir**<br>192.22 | 78<br>**Pt**<br>195.09 | 79<br>**Au**<br>196.97 | 80<br>**Hg**<br>200.59 | 81<br>**Tl**<br>204.37 | 82<br>**Pb**<br>207.19 | 83<br>**Bi**<br>208.98 | 84<br>**Po**<br>(210) | 85<br>**At**<br>(210) | 86<br>**Rn**<br>(222) |
| 87<br>**Fr**<br>(223) | 88<br>**Ra**<br>(226) | 89 ‡<br>**Ac**<br>(227) | | | | | | | | | | | | | | | |

Atomic number

**Element**

Relative atomic mass

† | 58<br>**Ce**<br>140.12 | 59<br>**Pr**<br>140.91 | 60<br>**Nd**<br>144.24 | 61<br>**Pm**<br>146.92 | 62<br>**Sm**<br>150.35 | 63<br>**Eu**<br>151.96 | 64<br>**Gd**<br>157.25 | 65<br>**Tb**<br>158.92 | 66<br>**Dy**<br>162.50 | 67<br>**Ho**<br>164.93 | 68<br>**Er**<br>167.26 | 69<br>**Tm**<br>168.93 | 70<br>**Yb**<br>173.04 | 71<br>**Lu**<br>174.97 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

‡ | 90<br>**Th**<br>232.04 | 91<br>**Pa**<br>231.04 | 92<br>U<br>238.03 | 93<br>**Np**<br>(237) | 94<br>**Pu**<br>(242) | 95<br>**Am**<br>(243) | 96<br>**Cm**<br>(247) | 97<br>**Bk**<br>(247) | 98<br>**Cf**<br>(251) | 99<br>**Es**<br>(254) | 100<br>**Fm**<br>(257) | 101<br>**Md**<br>(258) | 102<br>**No**<br>(259) | 103<br>**Lr**<br>(260) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

1.    What is the number of ions in 0.20 mol of $(NH_4)_3PO_4$?

A.    $8.0 \times 10^{-1}$

B.    $1.2 \times 10^{23}$

C.    $4.8 \times 10^{23}$

D.    $2.4 \times 10^{24}$

2.    The equation for the reduction of iron(III) oxide is:

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$
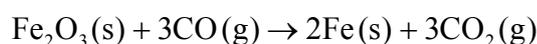
What mass of carbon dioxide, in g, is produced by the complete reduction of 80 g of iron(III) oxide?

A.    44

B.    66

C.    88

D.    132

3.    3.0 dm³ of ethyne, $C_2H_2$, is mixed with 3.0 dm³ of hydrogen and ignited.  The equation for the reaction that occurs is shown below.

$$C_2H_2(g) + 2H_2(g) \rightarrow C_2H_6(g)$$
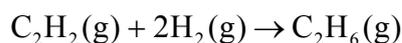
Assuming the reaction goes to completion and all gas volumes are measured at the same temperature and pressure, what volume of ethane, $C_2H_6$, in dm³, is formed?

A.    1.5

B.    2.0

C.    3.0

D.    6.0

**4.** Which ion would be deflected the most in a mass spectrometer?

A.    $^{35}Cl^{+}(g)$

B.    $^{37}Cl^{+}(g)$

C.    $^{35}Cl^{2+}(g)$

D.    $^{37}Cl^{2+}(g)$

**5.** Which of the graphs below shows the successive logarithmic ionization energies of phosphorus?

A.
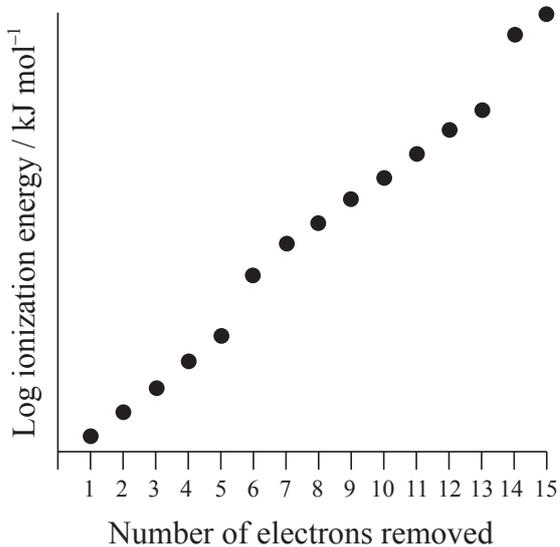
B.
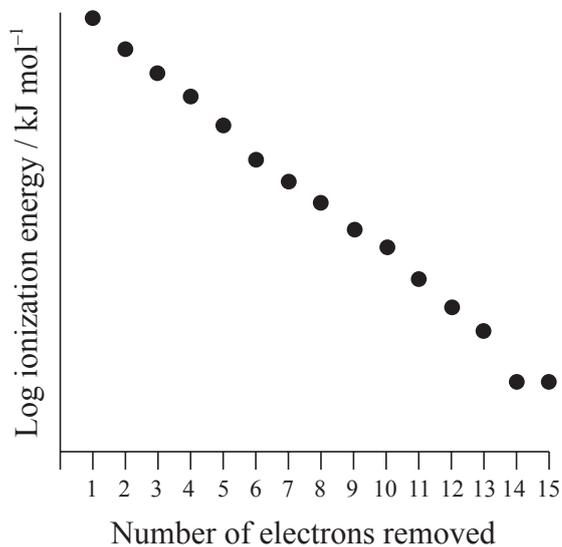
C.
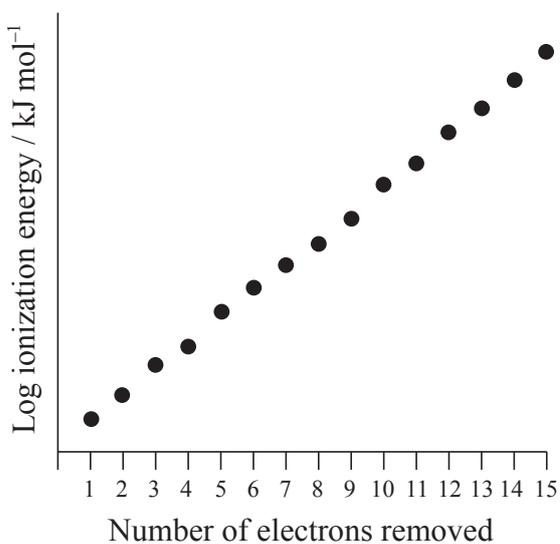
D.
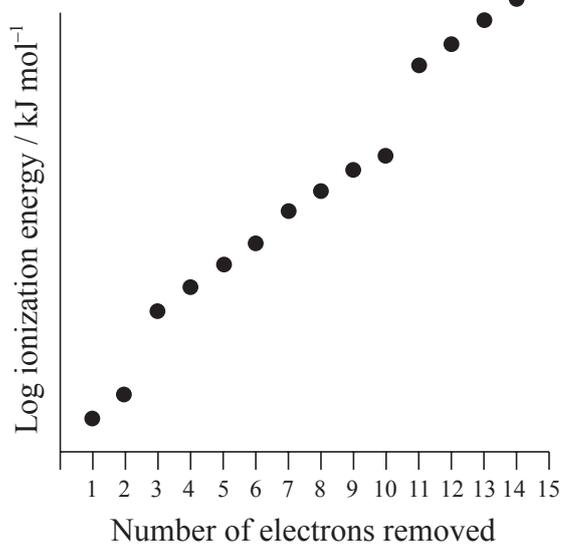
**6.** Which combination is correct for the properties of the alkali metals from Li to Cs?

|  | **Atomic radius** | **Melting point** | **First ionization energy** |
|---|---|---|---|
| A. | increases | increases | increases |
| B. | increases | decreases | decreases |
| C. | increases | increases | decreases |
| D. | decreases | decreases | increases |

**7.** Which equation represents a reaction that occurs under normal conditions?

A.    $2LiBr(aq) + I_2(aq) \rightarrow 2LiI(aq) + Br_2(aq)$

B.    $2KF(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + F_2(aq)$

C.    $2LiCl(aq) + I_2(aq) \rightarrow 2LiI(aq) + Cl_2(aq)$

D.    $2KBr(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + Br_2(aq)$

**8.** Which combination of statements about the oxides of period 3 elements is correct?

|  | **State at room temperature** | | | **Electrical conductivity in molten state** | | |
|---|---|---|---|---|---|---|
|  | $Na_2O$ | $Al_2O_3$ | $P_4O_{10}$ | $Na_2O$ | $Al_2O_3$ | $P_4O_{10}$ |
| A. | solid | solid | gas | good | good | good |
| B. | solid | solid | solid | good | good | poor |
| C. | solid | liquid | liquid | good | poor | poor |
| D. | solid | solid | solid | poor | poor | good |

**9.** Which is an ionic compound?

A. $Mg_3N_2$

B. $Al_2Cl_6$

C. $SiO_2$

D. $SF_6$

**10.** Which molecule is polar?

| | Molecule | Shape |
|---|---|---|
| A. | $CO_2$ | linear |
| B. | $SO_3$ | trigonal planar |
| C. | $CCl_4$ | tetrahedral |
| D. | $SO_2$ | bent (V-shaped) |

**11.** Which intermolecular forces are present in $HI(l)$?

     I. Hydrogen bonding

     II. Dipole-dipole forces

     III. Van der Waals' (London dispersion) forces

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**12.** In the molecule $SF_4$, which are the correct bond angles?
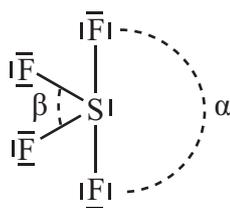


|  | $\alpha\ /\ °$ | $\beta\ /\ °$ |
|---|---|---|
| A. | 180 | 120 |
| B. | 187 | 103 |
| C. | 187 | 120 |
| D. | 180 | 90 |

**13.** Which substances have delocalized electrons in their structure?

    I.    Ethanal

    II.    Ozone

    III.    Benzene

A.    I and II only

B.    I and III only

C.    II and III only

D.    I, II and III

**14.** A 5.00 g sample of a substance was heated from 25.0 °C to 35.0 °C using $2.00 \times 10^2$ J of energy. What is the specific heat capacity of the substance in $J\ g^{-1}\ K^{-1}$?

A.    $4.00 \times 10^{-3}$

B.    $2.50 \times 10^{-1}$

C.    2.00

D.    4.00

**15.** Using the equations below:

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^{\ominus} = -390 \text{ kJ}$$
$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H^{\ominus} = -286 \text{ kJ}$$
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H^{\ominus} = -890 \text{ kJ}$$
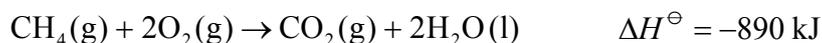
what is $\Delta H^{\ominus}$, in kJ, for the following reaction?

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$
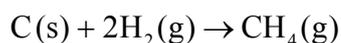
A. –214

B. –72

C. +72

D. +214

**16.** Which is the best definition of electron affinity?

A. The ability of an atom to attract the electrons in a covalent bond.

B. The attraction of an atom for an electron.

C. The enthalpy change when an atom gains an electron.

D. The enthalpy change when a gaseous atom gains an electron.

**17.** Which is the best definition of the standard state?

A. The standard state of a solid is the most pure form of the solid.

B. The standard state of a solid is the most pure form of the solid at $298\,°C$.

C. The standard state of a gas is the most pure form of the gas at $298\,°C$.

D. The standard state of a gas is the most pure form of the gas at a pressure of 100 kPa.

**18.** Consider the following information:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$
$$\Delta H = +179 \text{ kJ mol}^{-1}$$
$$\Delta S = +161.0 \text{ J K}^{-1} \text{mol}^{-1}$$

What happens to the spontaneity of this reaction as the temperature is increased?

A. The reaction becomes more spontaneous as the temperature is increased.

B. The reaction becomes less spontaneous as the temperature is increased.

C. The reaction remains spontaneous at all temperatures.

D. The reaction remains non-spontaneous at all temperatures.

**19.** Which piece of equipment could **not** be used in an experiment to measure the rate of this reaction?

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

A. A colorimeter

B. A gas syringe

C. A stopwatch

D. A pH meter

**20.** Which graph would be produced by a $2^{nd}$ order reaction if the rate equation is rate $= k[X]^2$ ?
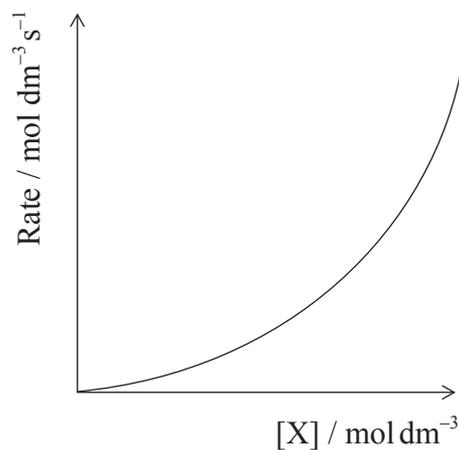
A.
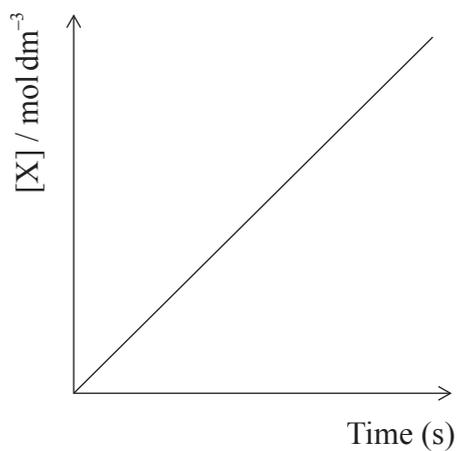


B.
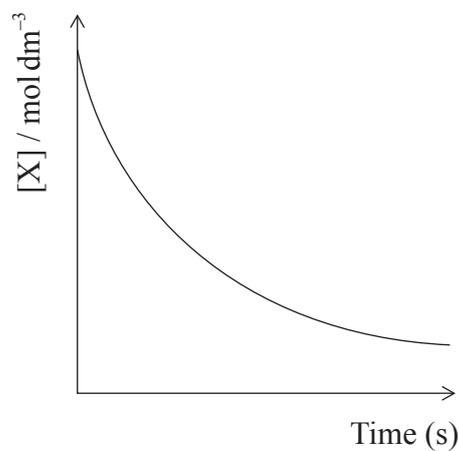


C.
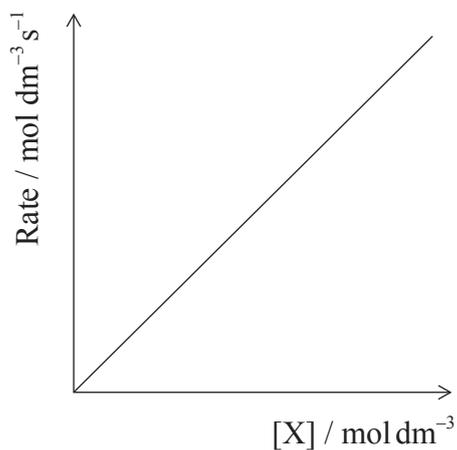


D.



**21.** Which step in a multi-step reaction mechanism will be rate-determining?

A.  The first step

B.  The last step

C.  The step with the highest activation energy

D.  The step with the lowest activation energy

**22.** Iron(III) ions, $Fe^{3+}$, react with thiocyanate ions, $SCN^-$, in a reversible reaction to form a red solution. Which changes to the equilibrium will make the solution go red?

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons [FeSCN]^{2+}(aq) \qquad \Delta H^{\ominus} = +ve$$

Yellow                     Red

    I.     Increasing the temperature

    II.    Adding $FeCl_3$

    III.   Adding a catalyst

A.    I and II only

B.    I and III only

C.    II and III only

D.    I, II and III

**23.** Consider the following reversible reaction:

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

What is the value of $K_c$ for the reaction when the equilibrium concentrations are $[NO_2] = 4.0 \, mol \, dm^{-3}$ and $[N_2O_4] = 4.0 \, mol \, dm^{-3}$ ?

A.    0.25

B.    0.50

C.    2.0

D.    4.0

**24.** Which substance can act as a Lewis acid but not as a Brønsted–Lowry acid?

A.    HCl

B.    $CH_3COOH$

C.    $BF_3$

D.    $CF_3COOH$

**Turn over**

**25.** Which row correctly describes $1.0 \text{ mol dm}^{-3} \text{ NaOH(aq)}$?

|  | pH | Colour in universal indicator solution | Electrical conductivity |
|---|---|---|---|
| A. | 14 | purple | good |
| B. | 10 | green | poor |
| C. | 14 | red | good |
| D. | 10 | blue | poor |

**26.** For pure water at $50 \text{ °C}$, $K_w = 5.48 \times 10^{-14}$. What is the pH of this water?

A.   4.8

B.   6.6

C.   7.0

D.   8.2

**27.** Which is the strongest acid?

|  | Acid | $pK_a$ |
|---|---|---|
| A. | chloroethanoic | 2.87 |
| B. | iodoethanoic | 3.18 |
| C. | benzoic | 4.20 |
| D. | pentanoic | 4.83 |

**28.** Which salts will dissolve in water to give solutions with a pH above 7?

      I.     $Na_2CO_3$

      II.    $CH_3COONa$

      III.   $Na_2SO_4$

   A.    I and II only

   B.    I and III only

   C.    II and III only

   D.    I, II and III

**29.** During a titration, $0.1 \ mol \ dm^{-3}$ sodium hydroxide is added to $0.1 \ mol \ dm^{-3}$ ethanoic acid. Which indicator would be the **best** to use as an end point indicator in this titration?

|     | Indicator | pH range of indicator |
|-----|-----------|-----------------------|
| A.  | methyl orange | 3.2–4.4 |
| B.  | bromophenol blue | 3.0–4.6 |
| C.  | bromothymol blue | 6.0–7.6 |
| D.  | phenolphthalein | 8.2–10.0 |

**30.** What is the correct systematic name of $MnO_2$?

   A.    Manganese(II) oxide

   B.    Manganese(IV) oxide

   C.    Magnesium(II) oxide

   D.    Magnesium(IV) oxide

**31.** A voltaic cell is made by connecting zinc and lead half-cells. The overall equation for the reaction occurring in the cell is shown below.

$$Zn\,(s) + Pb^{2+}(aq) \rightarrow Pb\,(s) + Zn^{2+}(aq)$$
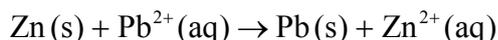
Which statements are correct when the cell produces electricity?

I.      The zinc is oxidized.

II.     Electrons move from zinc to lead in the external circuit.

III.    The mass of the lead electrode increases.

A.    I and II only

B.    I and III only

C.    II and III only

D.    I, II and III

**32.** Consider the following standard electrode potential values:

$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad\qquad\qquad E^{\ominus} = +0.77 \text{ V}$$
$$MnO_4^{\,-}(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O\,(l) \qquad E^{\ominus} = +1.51 \text{ V}$$
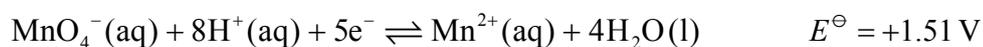
What is the cell potential, in V, for this reaction?

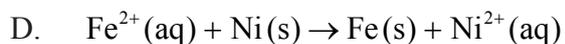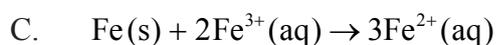$$MnO_4^{\,-}(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O\,(l) + 5Fe^{3+}(aq)$$
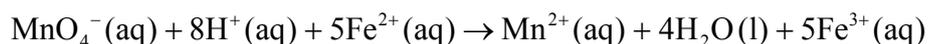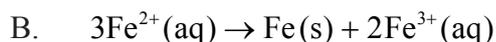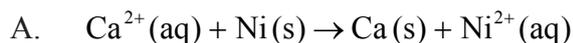
A.    −2.28

B.    −0.74

C.    +0.74

D.    +2.28

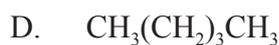**33.** Consider the following standard electrode potential values:

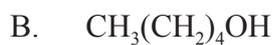$$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s) \qquad E^\ominus = -2.87 \text{ V}$$
$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s) \qquad E^\ominus = -0.45 \text{ V}$$
$$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s) \qquad E^\ominus = -0.26 \text{ V}$$
$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^\ominus = +0.77 \text{ V}$$
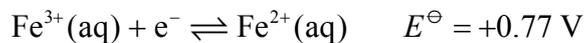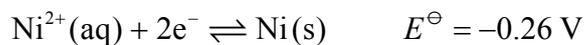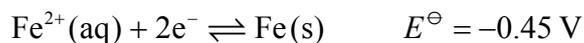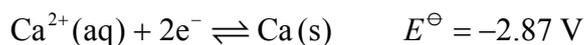
Which reaction is spontaneous?

A.  $Ca^{2+}(aq) + Ni(s) \rightarrow Ca(s) + Ni^{2+}(aq)$

B.  $3Fe^{2+}(aq) \rightarrow Fe(s) + 2Fe^{3+}(aq)$

C.  $Fe(s) + 2Fe^{3+}(aq) \rightarrow 3Fe^{2+}(aq)$

D.  $Fe^{2+}(aq) + Ni(s) \rightarrow Fe(s) + Ni^{2+}(aq)$

**34.** Which compound has the lowest boiling point?

A.  $(CH_3)_3COH$

B.  $CH_3(CH_2)_3OH$

C.  $(CH_3)_4C$

D.  $CH_3(CH_2)_3CH_3$
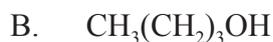
**35.** Which compound would decolourize bromine water in the dark?

A.  $CH_3COCH_2CH_3$

B.  $CH_3(CH_2)_4OH$

C.  $CH_3CHCHCH_3$

D.  $CH_3(CH_2)_3CH_3$
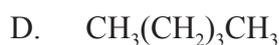
**36.** Which statement about the oxidation of alcohols is correct?

    A.    Oxidation of propan-1-ol produces propanone.

    B.    Mild oxidation of butan-1-ol produces butanal.

    C.    Strong oxidation of pentan-2-ol produces pentanoic acid.

    D.    Mild oxidation of butan-2-ol produces butanal.

**37.** Which halogenoalkane will react most quickly with sodium hydroxide?

    A.    $CH_3CH_2CH_2CH_2Cl$

    B.    $CH_3CH_2CH_2CH_2Br$

    C.    $(CH_3)_3CCl$

    D.    $(CH_3)_3CBr$

**38.** Which would be the main product of the reaction between 1-bromobutane and concentrated sodium hydroxide in hot ethanol?

    A.    $CH_2CHCH_2CH_3$

    B.    $CH_3CHCHCH_3$

    C.    $CH_3CH_2CH_2CH_3$

    D.    $CH_3CHOHCH_2CH_3$

**39.** Which molecules can react to form a condensation polymer with a dicarboxylic acid such as hexanedioic acid?

      I.     $HOCH_2CH_2OH$

      II.    $CH_3CH_2NH_2$

      III.   $H_2N(CH_2)_6NH_2$

A.    I and II only

B.    I and III only

C.    II and III only

D.    I, II and III

**40.** $50 \text{ cm}^3$ of copper(II) sulfate solution is measured into a plastic cup using a $100 \text{ cm}^3$ measuring cylinder. Excess zinc powder is added and the temperature rise that occurs is measured with a $-10\,°C$ to $+110\,°C$ thermometer. The enthalpy change for the reaction is then calculated. Which statement is correct?

A.    Systematic error will be reduced by repeating the experiment several times and averaging the results.

B.    Random error will be reduced by insulating the plastic cup.

C.    Random error will be reduced by using a $50 \text{ cm}^3$ graduated pipette instead of a measuring cylinder.

D.    Systematic error will be increased by using a larger volume of copper(II) sulfate solution.