



Baltic Chemistry Competition

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4TH ROUND, ANSWERS

Test name: Baltic Chemistry Competition 2010 4th round

This test is worth: 60 points

Select multiple choice answers with a cross or tick:

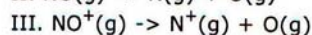
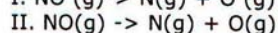
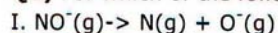


Only select one answer



Select multiple answers

Q1) For which of the following endothermic processes would be the energy requirement the largest?



a) I



b) II



c) III

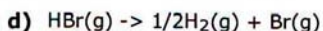
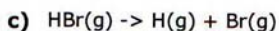
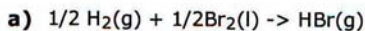


d) All are equal.

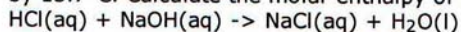


e) Not possible to determine, need more information.

Q2) The bond energy of hydrogen bromide is the change in enthalpy for the reaction:



Q3) When 0.050 mol of HCl is reacted with 0.050 mol of NaOH in 50.0 mL water, the temperature of water increases by 13.7°C. Calculate the molar enthalpy of neutralization:



The heat capacity of system is 209.2 J/°C.



a) -57300 J



b) -2870 J



c) +2870 J

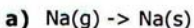


d) +57300 J



e) +115000 J

Q4) The enthalpy change for the following processes has the sign different from the rest?



- ☐ c) $\text{Cl(g)} + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- ☒ d) $\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$
- ☐ e) $\text{Cl}^+(\text{g}) + \text{e}^- \rightarrow \text{Cl}(\text{g})$

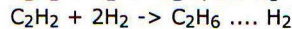
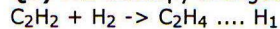
Q5) Calculate enthalpy change in kJ for the reaction:
 $\text{C}_2\text{H}_4 + \text{HCl} \rightarrow \text{C}_2\text{H}_5\text{Cl}$

Use following table:

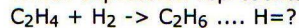
Bond	Cl-Cl	C-Cl	C-C	C-O	C-H	H-Cl	C=C	H-H
kJ/mol	243	326	347	351	414	431	619	435

- ☐ a) -451
- ☐ b) +310
- ☐ c) -309
- ☒ d) -37
- ☐ e) -468

Q6) The enthalpy changes for two different hydrogenation reactions of C_2H_2 are:

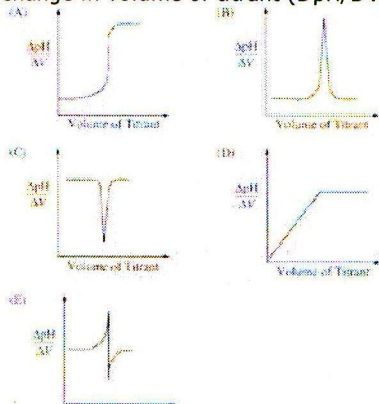


Which expression represents the enthalpy change for the reaction below?



- ☐ a) $H_1 + H_2$
- ☐ b) $H_1 - H_2$
- ☒ c) $H_2 - H_1$
- ☐ d) $-H_1 - H_2$
- ☐ e) $H_1 * H_2$

Q7) In plotting data from the potentiometric titration of strong acid with strong base, a plot of the change in pH per change in volume of titrant ($\Delta\text{pH}/\Delta V$) versus volume of titrant will have which of following shapes?



- ☐ a) A
- ☒ b) B
- ☐ c) C

d) D

e) E

Q8) The isomeric ketones shown bellow can be distinguished from each other by number of signals in ^{13}C NMR spectra. These ketones should show which of the following numbers of signals?



a) I - 3; II - 5

b) I - 3; II - 7

☒ c) I - 4; II - 7

d) I - 4; II - 3

e) I - 5; II - 7

Q9) A weak acid, HA, has a K_a of 1.00×10^{-5} . If 0.100 mole of this acid is dissolved in one liter of water, the percentage of acid dissociated at equilibrium is closest to:

a) 0.100 %

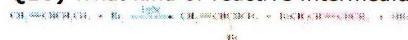
☒ b) 1.00 %

c) 99.0 %

d) 99.9 %

e) 100 %

Q10) What kind of reactive intermediate is formed in the reaction shown bellow?



a) Carbanion

b) Carbocation

c) Bromonium ion

d) Bromide ion

☒ e) Free radical

Q11) For the reaction $\text{O}_3(\text{g}) \rightarrow 1.5\text{O}_2(\text{g})$ Gibbs energy change is minus 163 kJ/mol. What is the value of equilibrium constant, K_p , for this reaction?

☒ a) $K_p > 1.0$

b) $K_p = 1.0$

c) $0 < K_p < 1.0$

d) $K_p = 0$

e) $K_p < 0$

$$\Delta G = -RT \ln K = -163000 \frac{\text{J}}{\text{mol}}$$

Q12) In an isolated hydrogen atom, the $2p_x$ orbital has the same principal quantum number, n , as which of the following orbitals?

- I. $2s$
- II. $2p_z$
- III. $2p_x$

- ☐ a) I only
- ☐ b) II only
- ☐ c) III only
- ☒ d) I and II only
- ☐ e) II and III only

Q13) Which of the following is NOT an allotrope of carbon?

- ☐ a) Diamond
- ☐ b) Graphite
- ☐ c) C_{60}
- ☐ d) C_{70}
- ☒ e) C_2^{2-}

Q14) Of the following covalent bonds, which has the greatest bond dissociation energy?

- ☐ a) $C=C$
- ☐ b) $O=O$
- ☐ c) $C=Si$
- ☐ d) $Si \equiv Si$ (\equiv means triple bond)
- ☒ e) $C \equiv O$ (\equiv means triple bond)

Q15) How many pi bonds are in acetylene molecule?

- ☐ a) 1
- ☒ b) 2
- ☐ c) 3
- ☐ d) 4
- ☐ e) 5

Q16) 1) $CHF_2CH_2CH_2COOH$

2) $CH_3CF_2CH_2COOH$

3) $CH_3CH_2CF_2COOH$

4) $CH_3CH_2CH_2COOH$

In which of the following are the carboxylic acids shown above listed in order of decreasing acidity, from most acidic to least acidic?

- ☐ a) $1 > 2 > 3 > 4$

- ☐ b) $1 > 4 > 3 > 2$
- ☒ c) $3 > 2 > 1 > 4$
- ☐ d) $3 > 4 > 1 > 2$
- ☐ e) $4 > 1 > 2 > 3$

Q17) Assuming that air is approximately 80% nitrogen and 20% oxygen by volume, which of the following is closest to the density of air at 0°C and 1 atmosphere?

- ☐ a) 0.01 g/L
- ☐ b) 0.1 g/L
- ☒ c) 1 g/L
- ☐ d) 10 g/L
- ☐ e) 100 g/L

Q18) The initial rates given below were determined for reaction $A + 2B \rightarrow AB_2$. What is the overall rate law for this reaction?

[A]	[B]	Initial Rate
0.50 M	0.50 M	10 M/s
0.50 M	1.00 M	20 M/s
0.25 M	0.50 M	5 M/s
1.00 M	1.00 M	40 M/s

- ☐ a) $\text{Rate} = k[A]^2[B]^2$
- ☐ b) $\text{Rate} = k[A]^2[B]$
- ☐ c) $\text{Rate} = k[A][B]^2$
- ☒ d) $\text{Rate} = k[A][B]$
- ☐ e) $\text{Rate} = k$

Q19) $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$

ΔH for the reaction shown above is greater than zero. Assuming ΔH is independent of temperature, which of the following statements about the percent yield of $CO(g)$ is true?

- ☐ a) It increases as amount of $C(s)$ increases.
- ☒ b) It increases as temperature increases.
- ☐ c) It decreases as temperature increases.
- ☐ d) It doubles when initial partial pressure of CO_2 is doubled.
- ☐ e) It increases when total pressure of reaction system increases.

Q20) At standard temperature and pressure, all of the following compounds exist in the gas state EXCEPT:

- ☐ a) HCl
- ☐ b) HBr
- ☐ c) NH_3
- ☐ d) BH_3
- ☒ e) LiH

Q21) The electron configuration of Co in $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ is:

- ☐ a) $[\text{Ar}]4s^23d^7$
- ☐ b) $[\text{Ar}]4s^23d^4$
- ☐ c) $[\text{Ar}]3d^9$
- ☐ d) $[\text{Ar}]3d^7$
- ☒ e) $[\text{Ar}]3d^6$

Q22) A 0.600 g sample of a pure, weak diprotic acid gives end points at 20.0 mL and 40.0 mL when it is titrated with 0.100 M NaOH. What is the relative molar mass of the weak acid?

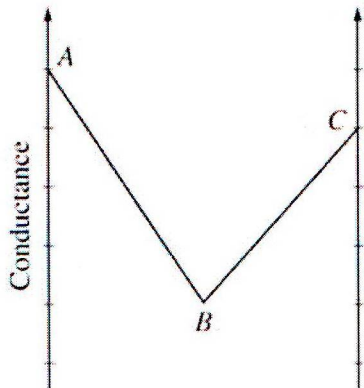
- ☐ a) 120
- ☐ b) 150
- ☐ c) 180
- ☒ d) 300
- ☐ e) 450

Q23) The molecular shape of IF_5 is:

- ☒ a) square pyramidal
- ☐ b) trigonal planar
- ☐ c) bent
- ☐ d) linear
- ☐ e) octahedral

Q24) At a given temperature, the vapour pressure of SiF_4 is significantly higher than that of SF_4 . The major physical basis for the difference in vapour pressure is that SiF_4 and SF_4 have different:

- ☒ a) dipole moments
- ☐ b) molar masses
- ☐ c) ionization energies
- ☐ d) electron affinities
- ☐ e) magnetic susceptibilities



Q25)

The figure shown above is a plot of conductance data obtained during titration of HCl with standard solution of NaOH. (If it is not seen: on x axis is shown volume of NaOH solution) Which of the following statements about results is NOT true?

- ☐ a) Point B is end point of titration.
- ☐ b) $|\text{slope AB}| > |\text{slope BC}|$
- ☐ c) The measured conductance increases after point B because the overall concentration of ions increases.
- ☒ d) Na^+ must have higher equivalent conductance than H_3O^+
- ☐ e) Segment BC represents the conductance due to ions from NaCl and NaOH in solution.

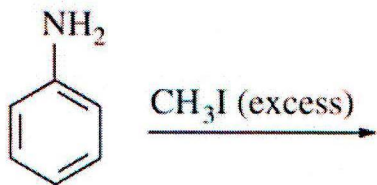
Q26) Sodium acetate spontaneously crystallizes out of supersaturated solution on standing or on the addition of a seed crystal. Which of the following is true for the thermodynamic quantities of this process?

(D mean Delta)

- ☒ a) $\Delta S < 0$, $\Delta H < 0$
- ☐ b) $\Delta S < 0$, $\Delta G > 0$
- ☐ c) $\Delta S > 0$, $\Delta H > 0$
- ☐ d) $\Delta S > 0$, $\Delta G < 0$
- ☐ e) $\Delta G < 0$, $\Delta H > 0$

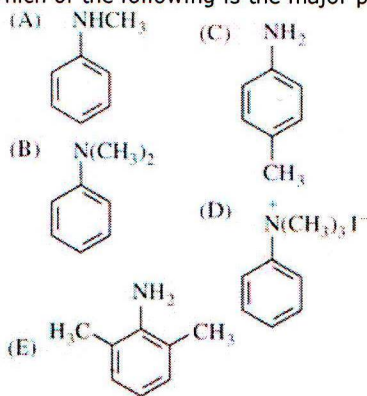
Q27) $\text{PbF}_2(\text{s})$, which is slightly soluble in water, is dissolved in water to form a saturated solution in equilibrium with solid PbF_2 . Which of the following will cause additional $\text{PbF}_2(\text{s})$ to dissolve?

- ☒ a) Adding HNO_3
- ☐ b) Adding $\text{Pb}(\text{NO}_3)_2$
- ☐ c) Adding seed crystal
- ☐ d) Adding solid $\text{PbF}_2(\text{s})$
- ☐ e) Evaporating some of the water to decrease the volume of solution



Q28)

Which of the following is the major product of the reaction shown above?



- ☐ a) A
☐ b) B
☐ c) C
☒ d) D
☐ e) E

Q29) What is the oxidation number of antimony (Sb) in caesium heptafluorodiantimonate, CsSb_2F_7 ?

- ☐ a) -1
☐ b) +1
☒ c) +3
☐ d) +5
☐ e) 0

Q30) An unknown compound was analysed by mass spectrometry. Compound has a molecular mass of 114 g/mol. An elemental analysis was also performed which showed that the compound contained 63% C, 9% H and 28% O by mass. Which one of the following compounds is it?

- ☒ a) $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{COOH}$
☐ b) $\text{CH}_3\text{CH}=\text{CHCH}_2\text{COOH}$
☐ c) $\text{CH}_3\text{COCH}_2\text{COCH}_2\text{CH}_3$
☐ d) $\text{CH}_2=\text{CHCOOCH}_2\text{CH}_3$
☐ e) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

Q31) What is the total number of isomers for a compound with molecular formula $C_3H_6Cl_2$?

- ☐ a) 3
- ☐ b) 4
- ☒ c) 5
- ☐ d) 6
- ☐ e) 7

Q32) If the percentage of water of crystallization in $CuSO_4 \cdot xH_2O$ is 36.1%, what is the value of x?

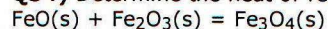
- ☐ a) 1
- ☐ b) 2
- ☐ c) 3
- ☐ d) 4
- ☒ e) 5

Q33) 20 mL of solution **X** was pipetted into a conical flask and titrated with solution **Y** from a burette. The pH was monitored with a pH meter throughout the experiment, and was plotted against the volume of solution **Y** added to give the graph below.

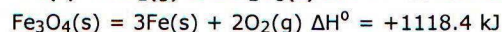
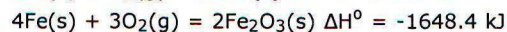
Which one of the following alternatives is most likely the identity of solutions **X** and **Y**?

- ☐ a) $X = KOH$, $Y = HCl$
- ☐ b) $X = NaOH$, $Y = CH_3COOH$
- ☐ c) $X = CH_3COOH$, $Y = NaHCO_3$
- ☒ d) $X = NaHCO_3$, $Y = HCl$
- ☐ e) $X = HCl$, $Y = NaHCO_3$

Q34) Determine the heat of reaction for the following process:



Given information:



- ☐ a) -1074.0 kJ
- ☐ b) -321.5 kJ
- ☒ c) -22.2 kJ
- ☐ d) +259.7 kJ
- ☐ e) +2214.6 kJ

Q35) The first four ionisation energies of an element **X** are 0.596 1.152, 4.918 and 6.480 MJ/mol. When **X** reacts with chlorine gas, what is the formula of the major product formed?

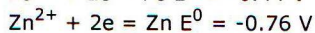
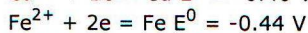
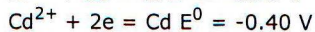
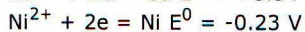
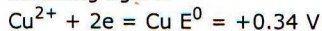
- ☐ a) QCl

- b) QCl_2
- c) QCl_3
- d) Q_2Cl_3
- e) Q_3Cl_4

Q36) Iodine binds to the double bonds in fatty acids. How many double bonds are in a molecule of α -linolenic acid, which has a molar mass of 278.4 g/mol, if 0.250 g of the acid requires 0.684 g of iodine for complete reaction?

- a) 1
- b) 2
- c) 3
- d) 4
- e) 5

Q37) The standard reduction potentials are given below for H_2O solutions. which of the species listed is the best oxidizing agent?



- a) Fe
- b) Fe^{2+}
- c) Cu^{2+}
- d) Zn^{2+}
- e) Zn

Q38) Which one of the following series is arranged in order of increasing ionic radius?

- a) $\text{Mg}^{2+} < \text{S}^{2-} < \text{Cl}^- < \text{K}^+ < \text{Ca}^{2+}$
- b) $\text{S}^{2-} < \text{Mg}^{2+} < \text{Ca}^{2+} < \text{Cl}^- < \text{K}^+$
- c) $\text{S}^{2-} < \text{Cl}^- < \text{K}^+ < \text{Mg}^{2+} < \text{Ca}^{2+}$
- d) $\text{Ca}^{2+} < \text{Cl}^- < \text{K}^+ < \text{Mg}^{2+} < \text{S}^{2-}$
- e) $\text{Mg}^{2+} < \text{Ca}^{2+} < \text{K}^+ < \text{Cl}^- < \text{S}^{2-}$

Q39) Which of the following compounds is NOT aromatic?



- a) A
- b) B

- ☐ c) C
- ☐ d) D
- ☒ e) E

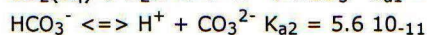
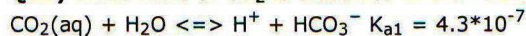
Q40) How many different ^{13}C NMR and ^1H NMR signals does 1-isopropyl-4-methyl-benzene organic molecule produce?

- ☐ a) 5 different carbon and 5 different hydrogen signals
- ☐ b) 6 different carbon and 7 different hydrogen signals
- ☒ c) 7 different carbon and 5 different hydrogen signals
- ☐ d) 7 different carbon and 6 different hydrogen signals
- ☐ e) 10 different carbon and 6 different hydrogen signals

Q41) Which of the metal ions in the following complex ions has a d^5 electronic configuration?

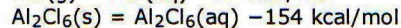
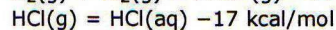
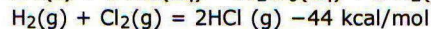
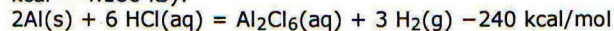
- ☐ a) RhCl_6^{4-}
- ☐ b) $\text{Mo}(\text{NH}_3)_6^{3+}$
- ☐ c) $\text{Co}(\text{CN})_4^-$
- ☒ d) $\text{Fe}(\text{CN})_6^{3-}$
- ☐ e) $\text{V}(\text{H}_2\text{O})_6^{2+}$

Q42) 0.020 mole of CO_2 is dissolved in 1.0 litre of pure water. What is the H^+ concentration in mole/litre?



- ☐ a) 0.020
- ☐ b) 0.040
- ☒ c) 9.3×10^{-5}
- ☐ d) 1×10^{-7}
- ☐ e) 1.2×10^{-11}

Q43) Calculate the enthalpy of formation of anhydrous aluminium chloride, $\text{Al}_2\text{Cl}_6(\text{s})$, from the following data (1 kcal = 4.186 kJ):



- ☐ a) -234 kJ/mol
- ☒ b) -1340 kJ/mol
- ☐ c) -1557 kJ/mol
- ☐ d) +645 kJ/mol
- ☐ e) +1557 kJ/mol

Q44) How many molecules are present in a 9.0 g sample of water?

- ☐ a) 0.5
- ☐ b) 1.0
- ☐ c) 6.0×10^{23}
- ☒ d) 3.0×10^{23}
- ☐ e) 4.5×10^{23}

Q45) What is the maximum mass of iron that can be produced from the reduction of 80 tonnes of iron(III)oxide?

- ☐ a) 28 tonnes
- ☒ b) 56 tonnes
- ☐ c) 82 tonnes
- ☐ d) 84 tonnes
- ☐ e) 112 tonnes

Q46) Which processes occur in the mass spectrometer?

- I. Ionization by electron bombardment
- II. Acceleration by a magnetic field
- III. Deflection by a magnetic field

- ☐ a) I and II only
- ☒ b) I and III only
- ☐ c) II and III only
- ☐ d) I, II and III
- ☐ e) None of all

Q47) Which properties decrease in value when descending group 1?

- I. Atomic radius
- II. Ionization energy
- III. Electronegativity

- ☐ a) I and II only
- ☐ b) I and III only
- ☒ c) II and III only
- ☐ d) I, II and III
- ☐ e) None of all

Q48) Which trend is correct when the elements are considered from left to right across period 3?

- ☐ a) The acidic character of the oxides decreases.
- ☐ b) The electrical conductivity of the elements increases.
- ☒ c) The bonding of the chlorides changes from ionic to covalent.
- ☐ d) Electronegativity decreases.

Q49) Which substance will not conduct an electric current?

- ☐ a) C (s) (graphite)
- ☐ b) NaF (l)
- ☒ c) CaO (s)
- ☐ d) KI (aq)
- ☐ e) H₂SO₄(aq)

Q50) Which of the following liquids is non-polar?

- ☐ a) Water
- ☒ b) Hexane
- ☐ c) Propanone
- ☐ d) Ethanol
- ☐ e) Acetone

Q51) What is the bond angle in NO₃⁻?

- ☐ a) 107°
- ☐ b) 109.5°
- ☒ c) 120°
- ☐ d) 180°
- ☐ e) variable

Q52) The temperature of 1 dm³ of a gas is increased from 2°C to 64°C at constant pressure. What is the new volume in dm³?

- ☒ a) 1.1
- ☐ b) 1.2
- ☐ c) 1.3
- ☐ d) 1.6
- ☐ e) 2.0

Q53) Which change does not lead to an increase in entropy?

- ☐ a) Mixing nitrogen and oxygen gases at room temperature
- ☒ b) Cooling steam so that it condenses to water
- ☐ c) Heating hexane to its boiling point
- ☐ d) Dissolving sugar in water

Q54) Which change increases the pH of a solution from 3 to 6?

- ☐ a) Doubling the $[H^+]$
- ☐ b) Halving the $[OH^-]$
- ☒ c) Decreasing the $[H^+]$ by a factor of 1000
- ☐ d) Decreasing the $[OH^-]$ by a factor of 1000
- ☐ e) Adding 1 mole of conjugate base.

Q55) Which pair of compounds, in aqueous solution, could be used to make a buffer solution?

- ☐ a) CH_3COOH and HCl
- ☐ b) HCl and $NaOH$
- ☐ c) HCl and NH_4Cl
- ☒ d) $HCOOH$ and $NaOH$
- ☐ e) H_2SO_4 and HCl

Q56) During the electrolysis of aqueous sulfuric acid, 1g of hydrogen gas forms at the negative electrode. What mass in grams of oxygen forms at the positive electrode in the same time?

- ☐ a) 4
- ☒ b) 8
- ☐ c) 16
- ☐ d) 32
- ☐ e) 48

Q57) Which compound cannot be easily oxidized using acidified potassium dichromate(VI) solution?

- ☐ a) $CH_3CH_2CH_2OH$
- ☐ b) $CH_3CH(OH)CH_3$
- ☐ c) $(CH_3)_2CHCH_2OH$
- ☒ d) $(CH_3)_3COH$
- ☐ e) CH_3CH_2COH

Q58) Which species cannot act as a nucleophile?

- ☐ a) H_2O
- ☐ b) NH_3
- ☒ c) CH_4
- ☐ d) CN^-
- ☐ e) Cl^-

Q59) Which halogenoalkane reacts most rapidly with silver nitrate solution to form a precipitate?

- ☐ a) 1-bromobutane
- ☐ b) 1-iodobutane
- ☐ c) 2-bromo-2-methylpropane
- ☒ d) 2-iodo-2-methylpropane
- ☐ e) Halogenoalkanes does not react with salt solutions.

Q60) What type of reaction occurs when hexanedioic acid and 1,6-diaminohexane react together to form nylon?

- ☐ a) Addition
- ☒ b) Condensation
- ☐ c) Esterification
- ☐ d) Substitution
- ☐ e) Elimination