N08/4/CHEMI/HPM/ENG/TZ0/XX

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CHEMISTRY
HIGHER LEVEL
PAPER 1

Tuesday 11 November 2008 (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.

8808-6101

The Periodic Table

Atomic Number **Element** Atomic Mass

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

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

1. Analytical chemists can detect amounts of amino acids as small as 2.0×10^{-21} mol of molecules. How many molecules does this represent?

A. 2.0×10^{-21}

B. 1.2×10^{3}

C. 6.0×10^{23}

D. 3.0×10^{44}

2. What amount of solute ions, in moles, is present in 50 cm^3 of 0.10 $mol\,dm^{-3}$ sodium hydroxide solution?

A. 2.5×10^{-3}

B. 5.0×10^{-3}

C. 1.0×10^{-2}

D. 5.0×10^{-2}

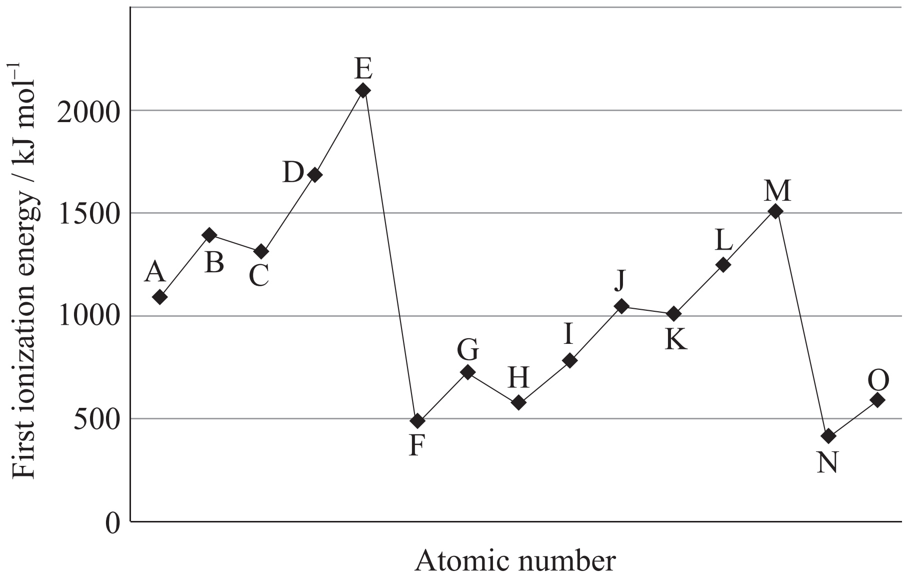
3. A blast furnace contains 1600 kg of iron(III) oxide (M_r=160) and 144 kg of carbon (A_r=12). Assuming that they react according to the following equation:

$$Fe_2O_3(s) + 3C(s) \rightarrow 2Fe(s) + 3CO(g)$$

what is the limiting reagent and the maximum theoretical yield of iron?

	Limiting reagent	**Maximum theoretical yield of iron / kg**
A.	iron(III) oxide	560
B.	iron(III) oxide	1120
C.	carbon	224
D.	carbon	448

4. The first ionization energies of successive elements in the periodic table are shown below.



Which statements are correct?

I. Elements E and M are in Group 0 of the periodic table.

II. Atoms of elements G and O have the outer electron configuration ns^2.

III. Atoms of elements B and J contain half-filled p orbitals.

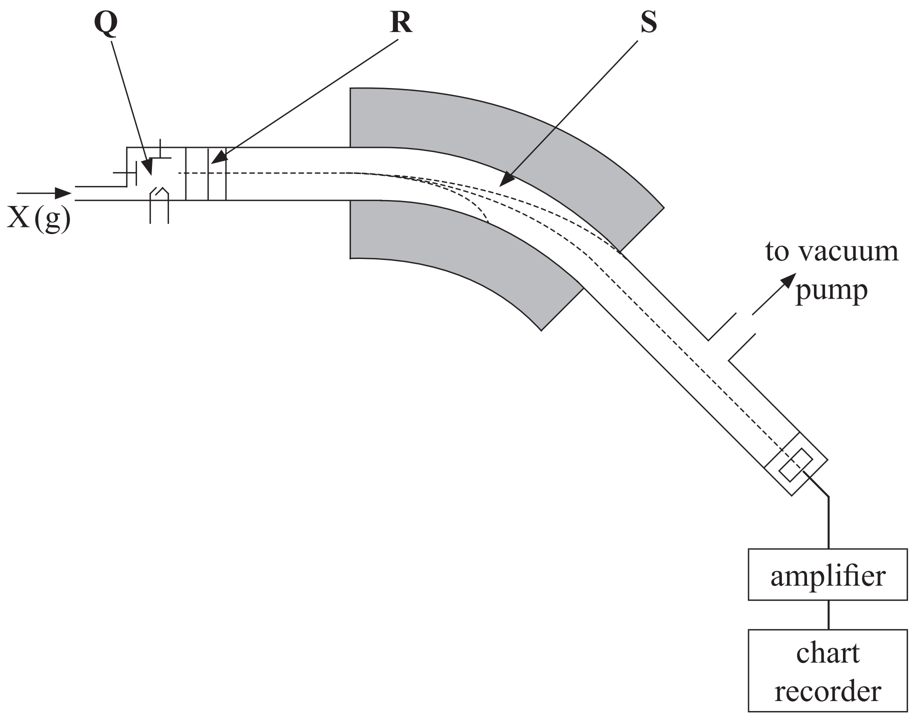
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

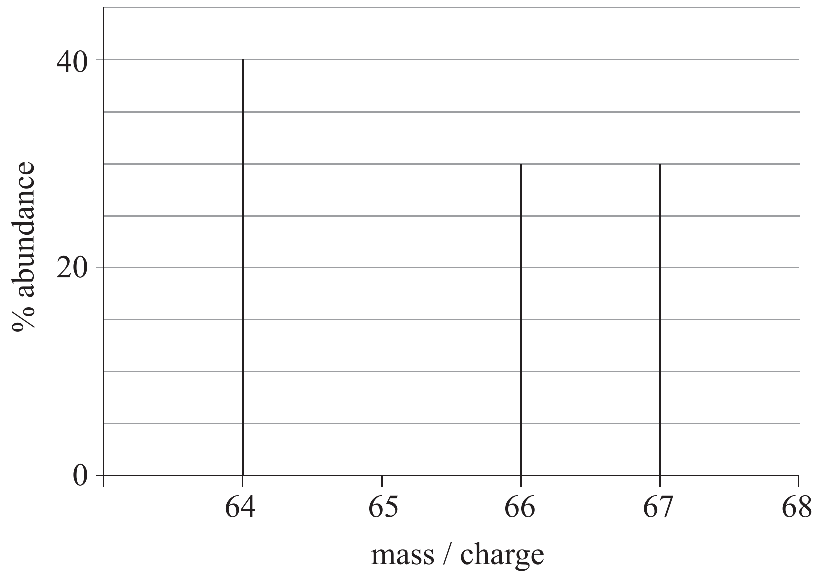
5. A representation of a mass spectrometer is shown below.



Which is the best description of the processes occurring at **Q**, **R** and **S** when element X(g) is analyzed?

	Q	**R**	**S**
A.	electric field applied	$X(g) + e^- \rightarrow X^+(g) + 2e^-$	magnetic field applied
B.	magnetic field applied	electric field applied	$X(g) + e^- \rightarrow X^+(g) + 2e^-$
C.	$X(g) + e^- \rightarrow X^+(g) + 2e^-$	electric field applied	magnetic field applied
D.	$X(g) + e^- \rightarrow X^+(g) + 2e^-$	magnetic field applied	electric field applied

6. The mass spectrum of a sample of an element is shown below.



Which value is closest to the relative atomic mass of the element?

A. 64.5

B. 65.0

C. 65.5

D. 66.0

7. In what order are the elements listed in the periodic table?

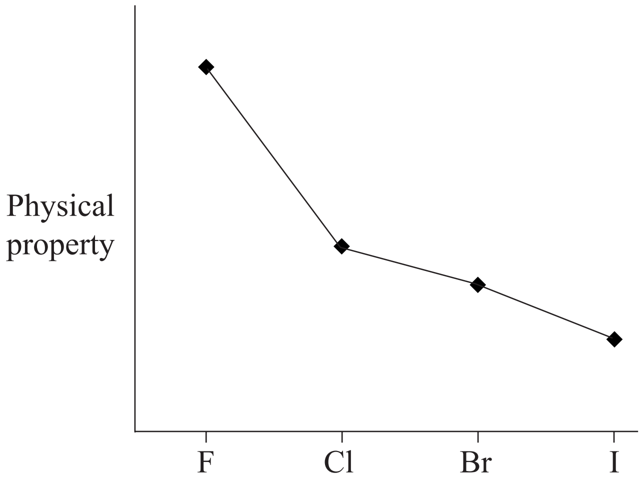
A. In order of relative atomic mass

B. In order of reactivity

C. In order of nuclear charge

D. In order of electronegativity

8. The graph shows the trend in a physical property down group 7 in the periodic table.



What is the physical property?

A. Atomic radius

B. Electronegativity

C. Density

D. Melting point

9. Which species can act as ligands with transition metal ions?

I. NH_3
II. Cl^-
III. CH_4

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

10. Equal amounts of four substances are added to separate samples of 100 cm^3 of water. Which solution has the highest pH?

A. NaCl

B. $AlCl_3$

C. PCl_3

D. Cl_2

11. The table shows the boiling points of the hydrogen halides.

Compound	**Boiling point / °C**
HF	20
HCl	−85
HBr	−67
HI	−35

Which statement explains the higher boiling point of hydrogen fluoride?

A. The covalent bond in hydrogen fluoride is stronger than those in the other hydrogen halides.

B. There is strong hydrogen bonding between the hydrogen fluoride molecules.

C. Fluorine is the most reactive element in group 7.

D. Fluorine has the highest first ionization energy in group 7.

12. Which substance has the lowest electrical conductivity?

A. Al(s)

B. Al_2O_3(l)

C. KCl(aq)

D. HCl(g)

13. Which bond has the lowest polarity?

A. C−H in methane, CH_4

B. C=O in carbon dioxide, CO_2

C. C−C in ethane, C_2H_6

D. C−C in ethanol, C_2H_5OH

14. What is the correct description of hybridization present in buta-1,3-diene, $H_2C{=}CH{-}CH{=}CH_2$?

A. sp

B. sp^2

C. sp and sp^2

D. sp^3, sp^2 and sp

15. Which molecules contain a bond angle of 90°?

I. PF_5
II. $SiCl_4$
III. SF_6

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

16. 75 cm^3 of an unknown gas has a mass of 0.18 g at a temperature of 25°C and a pressure of 1 atm. Which is the correct expression for the molar mass, *M*, in g mol^{-1} of the gas? ($R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$, $1 \text{ atm} = 1.01 \times 10^5$ Pa)

A. $M = \dfrac{0.18 \times 8.3 \times 25}{1 \times 75}$

B. $M = \dfrac{75 \times 10^{-6} \times 8.3 \times 25}{1.01 \times 10^5 \times 298}$

C. $M = \dfrac{0.18 \times 8.3 \times 298}{1.01 \times 10^5 \times 75 \times 10^{-6}}$

D. $M = \dfrac{1.01 \times 10^5 \times 75 \times 10^{-6}}{0.18 \times 8.3 \times 298}$

17. The average bond enthalpy for the C–H bond is 412 kJ mol^{-1}. Which process has an enthalpy change closest to this value?

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

B. $CH_4(g) \rightarrow C(g) + 2H_2(g)$

C. $CH_4(g) \rightarrow C(g) + 4H(g)$

D. $CH_4(g) \rightarrow CH_3(g) + H(g)$

18. A reaction has a positive $\Delta H^{\ominus}$ and a negative $\Delta S^{\ominus}$ value. Which statement about this reaction is correct?

A. It is not spontaneous at any temperature.

B. It is spontaneous at all temperatures.

C. It is spontaneous only at low temperatures.

D. It is spontaneous only at high temperatures.

19. When 50 cm^3 of 1.0 $mol\,dm^{-3}$ nitric acid solution, $HNO_3(aq)$, is added to 50 cm^3 of 1.0 $mol\,dm^{-3}$ potassium hydroxide solution, $KOH(aq)$, the temperature of the mixture increases by 6.4 °C. What will be the temperature change when 25 cm^3 of each of these solutions are mixed together?

A. 1.6 °C

B. 3.2 °C

C. 6.4 °C

D. 12.8 °C

20. Which features of a positive ion lead to a higher lattice enthalpy in its compounds?

I. A higher charge on the ion

II. A smaller ionic radius

III. A lower first ionization energy of the metal to form the ion

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

21. This reaction was used in flash photography:

$$3Mg(s) + KClO_3(s) \rightarrow 3MgO(s) + KCl(s)$$

Relevant enthalpy changes of formation values are shown below.

Compound	$\Delta H_f^{\ominus}$ **/ kJ mol^{-1}**
$KClO_3(s)$	−391
$MgO(s)$	−602
$KCl(s)$	−437

What is the enthalpy change, in kJ, of this reaction?

A. –1852

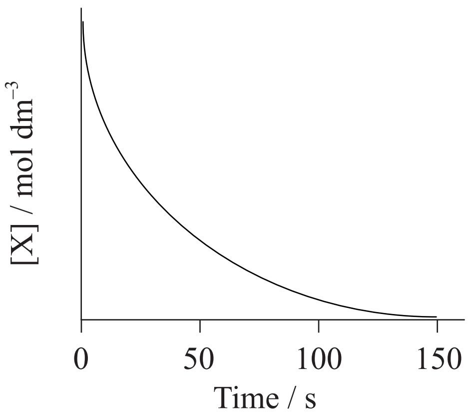
B. –648

C. +740

D. +1760

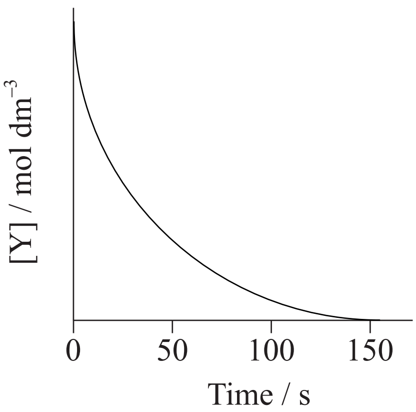
22. The graph below shows how the concentration of X changes with time during the following reaction:

$$X \rightarrow Y$$

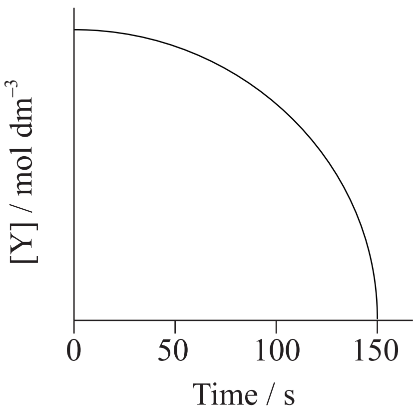


Which graph shows the change in concentration of Y during the same time period?

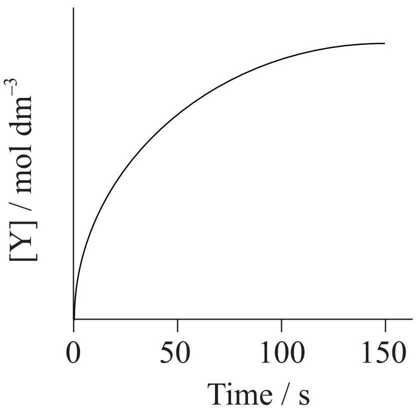
A.



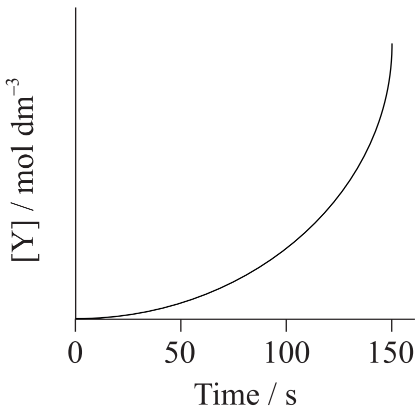
B.



C.



D.



23. The activation energy for a reaction can be determined graphically using the Arrhenius equation:

$$k = Ae^{\frac{-E_a}{RT}}$$

Which plot gives a straight line graph?

	Vertical axis	Horizontal axis
A.	k	$\frac{1}{T}$
B.	k	$\ln \frac{1}{T}$
C.	$\ln k$	$\ln \frac{1}{T}$
D.	$\ln k$	$\frac{1}{T}$

24. Nitrogen dioxide can react with carbon monoxide in the exhaust gases of car engines:

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

The following mechanism has been proposed:

$NO_2(g) + NO_2(g) \rightarrow N_2O_4(g)$ *slow*

$N_2O_4(g) + CO(g) \rightarrow NO_2(g) + CO_2(g) + NO(g)$ *fast*

What is the rate equation for this mechanism?

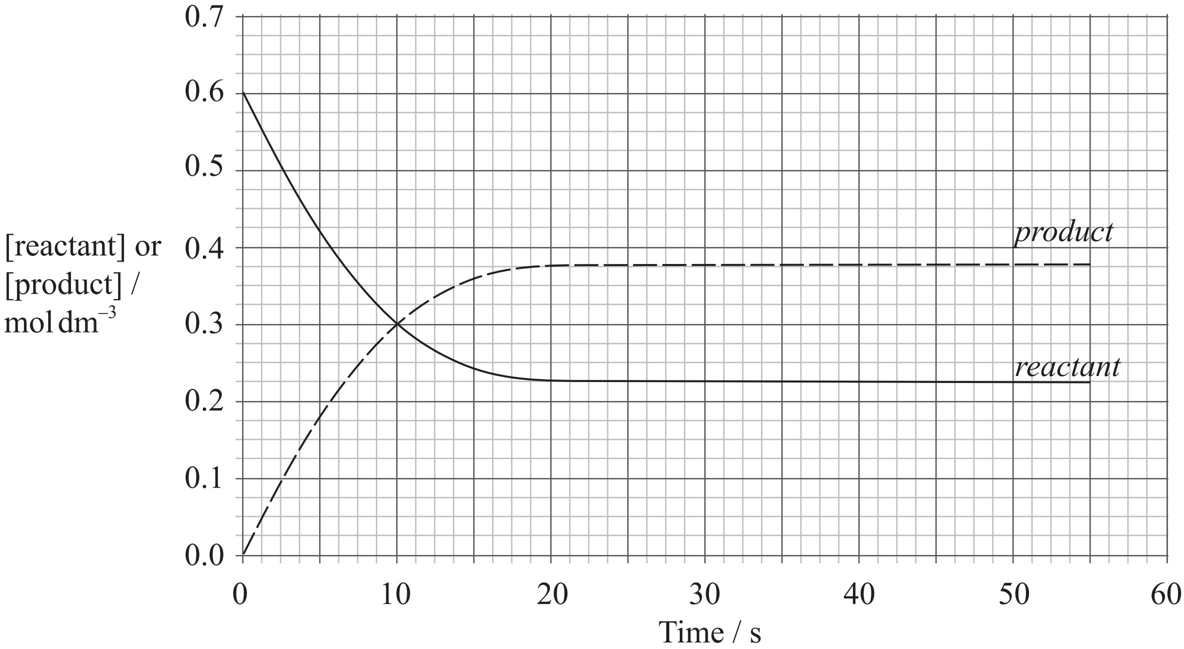
A. Rate $= k\ [NO_2(g)]\ [CO(g)]$

B. Rate $= k\ [NO_2(g)]^2$

C. Rate $= k\ [N_2O_4(g)]\ [CO(g)]$

D. Rate $= k\ [NO_2(g)]^2\ [CO(g)]$

25. The graph below shows how the concentrations of the reactant and product in a reversible reaction change with time.



When is the reaction at equilibrium?

I. Time = 10 s

II. Time = 20 s

III. Time = 55 s

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

26. Liquid bromine and its vapour are at equilibrium inside a sealed container:

$$Br_2(l) \rightleftharpoons Br_2(g)$$

Which change increases the equilibrium concentration of bromine vapour?

A. Adding more liquid bromine

B. Removing some liquid bromine

C. Decreasing the volume of the container

D. Increasing the temperature

27. The equation for a reversible process can be represented in two ways:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad K_{c1}$$

$$HI(g) \rightleftharpoons \tfrac{1}{2}H_2(g) + \tfrac{1}{2}I_2(g) \qquad K_{c2}$$

What is the relationship between the equilibrium constants K_{c1} and K_{c2}?

A. $K_{c1} = K_{c2}$

B. $K_{c1} = \dfrac{1}{2K_{c2}}$

C. $K_{c1} = \dfrac{1}{2K_{c2}^{2}}$

D. $K_{c1} = \dfrac{1}{K_{c2}^{2}}$

28. Which combinations form buffer solutions?

I. 50 cm^3 of 0.1 $mol\,dm^{-3}$ $CH_3COOH(aq)$ + 25 cm^3 of 0.1 $mol\,dm^{-3}$ $NaOH(aq)$

II. 50 cm^3 of 0.1 $mol\,dm^{-3}$ $CH_3COOH(aq)$ + 50 cm^3 of 0.1 $mol\,dm^{-3}$ $NaOH(aq)$

III. 50 cm^3 of 0.1 $mol\,dm^{-3}$ $CH_3COOH(aq)$ + 50 cm^3 of 0.1 $mol\,dm^{-3}$ $CH_3COONa(aq)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. What is the definition of a Brønsted-Lowry acid?

A. A substance which accepts protons

B. A substance which reacts with OH^- ions

C. A substance which has a pH below 7

D. A substance which donates H^+ ions

30. Which species can act as an acid according to the Lewis theory but not according to the Brønsted-Lowry theory?

A. NCl_3

B. HCl

C. H_2O

D. BF_3

31. Which salt produces the most acidic aqueous solution?

A. KCl

B. $FeCl_3$

C. CH_3COONa

D. $NaNO_3$

32. In which compound does manganese have the highest oxidation number?

A. $MnCl_2$

B. MnO_2

C. Mn_2O_3

D. $MnSO_4$

33. Which statement about the electrolysis of molten sodium bromide is correct?

A. Bromide ions lose electrons at the negative electrode.

B. Bromide ions gain electrons at the positive electrode.

C. Bromide ions gain electrons at the negative electrode.

D. Bromide ions move even if there is no current.

34. What is the coefficient for H^+ in the following equation?

$$3Cu(s) + \_\ NO_3^-(aq) + \_\ H^+(aq) \rightarrow \_\ Cu^{2+}(aq) + \_\ NO(g) + \_\ H_2O(l)$$

A. 4

B. 8

C. 12

D. 16

35. Which conditions apply to the standard hydrogen electrode?

I. Hydrogen at a pressure of 1.01×10^5 Pa (1 atm)

II. Hydrogen at a temperature of 298 K

III. $1.00\ mol\,dm^{-3}\ H_2SO_4(aq)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

36. Which of the following can form an addition polymer?

A. Alanine (2-aminopropanoic acid)

B. Butane

C. But-2-ene

D. 1,2-dichlorobutane

37. Which compound, when hydrogenated, gives a product with a chiral centre?

A. $CH_2=CH_2$

B. $CH_3CBr=CH_2$

C. $CH_3CH_2CBr=CH_2$

D. $CH_3CH_2C(CH_3)=CH_2$

38. Which statement about the reactions between halogenoalkanes and aqueous sodium hydroxide is correct?

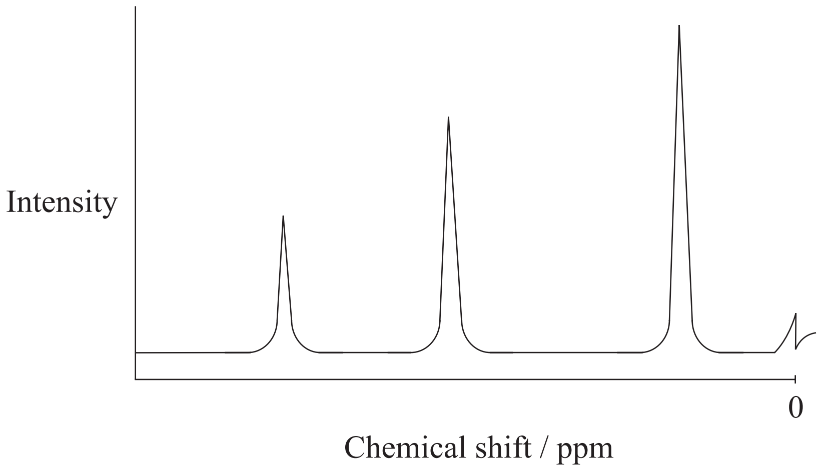
A. The reactions involve the homolytic fission of the carbon-halogen bond.

B. Chloroalkanes react faster than iodoalkanes.

C. The reactions of primary halogenoalkanes generally involve a two-step mechanism.

D. Tertiary halogenoalkanes generally react by a S_N1 mechanism.

39. An unknown organic compound gives the ^{1}H low resolution nuclear magnetic spectrum below. The peak at 0 ppm is due to the TMS reference.



Identify the organic compound.

A. $CH_3CH_2CH_3$

B. CH_2OHCH_2OH

C. CH_3CH_2OH

D. CH_3CH_2Cl

40. Which products are formed by the dehydration of butan-2-ol?

I. butane

II. but-1-ene

III. but-2-ene

A. I and II only

B. I and III only

C. II and III only

D. I, II and III