American University of Beirut

Faculty of Arts and Sciences

CHEMISTRY DEPARTMENT

LAST NAME: k f r

FI | MI

ID NUMBER

	T ①	F ②						T ①	F ②					
1	A	B	C	D	●	F		51	A	B	C	D	E	F
2	A	●	C	D	E	F		52	A	B	C	D	E	F
3	A	B	●	D	E	F		53	A	B	C	D	E	F
4	●	B	C	D	E	F		54	A	B	C	D	E	F
5	A	B	●	D	E	F		55	A	B	C	D	E	F
6	●	B	C	D	E	F		56	A	B	C	D	E	F
7	A	B	C	●	E	F		57	A	B	C	D	E	F
8	A	●	C	D	E	F		58	A	B	C	D	E	F
9	A	●	C	D	E	F		59	A	B	C	D	E	F
10	A	B	●	D	E	F		60	A	B	C	D	E	F
11	A	B	●	D	E	F		61	A	B	C	D	E	F
12	A	B	C	●	E	F		62	A	B	C	D	E	F
13	A	●	C	D	E	F		63	A	B	C	D	E	F
14	A	B	C	D	●	F		64	A	B	C	D	E	F
15	A	B	●	D	E	F		65	A	B	C	D	E	F
16	●	B	C	D	E	F		66	A	B	C	D	E	F
17	A	B	C	D	●	F		67	A	B	C	D	E	F
18	A	B	●	D	E	F		68	A	B	C	D	E	F
19	A	B	●	D	E	F		69	A	B	C	D	E	F
20	A	B	●	D	E	F		70	A	B	C	D	E	F
21	●	B	C	D	E	F		71	A	B	C	D	E	F
22	A	B	C	D	●	F		72	A	B	C	D	E	F
23	A	B	●	D	E	F		73	A	B	C	D	E	F
24	A	●	C	D	E	F		74	A	B	C	D	E	F
25	●	B	C	D	E	F		75	A	B	C	D	E	F
26	●	B	C	D	E	F		76	A	B	C	D	E	F
27	A	B	●	D	E	F		77	A	B	C	D	E	F
28	A	B	●	D	E	F		78	A	B	C	D	E	F
29	●	B	C	D	E	F		79	A	B	C	D	E	F
30	●	B	C	D	E	F		80	A	B	C	D	E	F
31	A	B	C	D	●	F		81	A	B	C	D	E	F
32	A	●	C	D	E	F		82	A	B	C	D	E	F
33	A	B	●	D	E	F		83	A	B	C	D	E	F
34	●	B	C	D	E	F		84	A	B	C	D	E	F
35	A	B	C	D	E	F		85	A	B	C	D	E	F
36	A	B	C	D	E	F		86	A	B	C	D	E	F
37	A	B	C	D	E	F		87	A	B	C	D	E	F
38	A	B	C	D	E	F		88	A	B	C	D	E	F
39	A	B	C	D	E	F		89	A	B	C	D	E	F
40	A	B	C	D	E	F		90	A	B	C	D	E	F
41	A	B	C	D	E	F		91	A	B	C	D	E	F
42	A	B	C	D	E	F		92	A	B	C	D	E	F
43	A	B	C	D	E	F		93	A	B	C	D	E	F
44	A	B	C	D	E	F		94	A	B	C	D	E	F
45	A	B	C	D	E	F		95	A	B	C	D	E	F
46	A	B	C	D	E	F		96	A	B	C	D	E	F
47	A	B	C	D	E	F		97	A	B	C	D	E	F
48	A	B	C	D	E	F		98	A	B	C	D	E	F
49	A	B	C	D	E	F		99	A	B	C	D	E	F
50	A	B	C	D	E	F		100	A	B	C	D	E	F

USE No. 2 OR HB PENCIL ONLY

EXAMPLES	IMPORTANT DIRECTIONS FOR MARKING ANSWERS
WRONG Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	• Use black lead pencil only (N° 2 or HB)
WRONG Ⓐ Ⓑ ✓ Ⓓ Ⓔ	• Do NOT use ink or ballpoint pens
WRONG Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	• Make heavy black marks that fill the circle completely
RIGHT Ⓐ Ⓑ Ⓒ ● Ⓔ	• Erase clearly any answer you wish to change
	• Make no stray marks on the answer sheet

1. If the concentration of ClO in air at 27°C and total pressure of 1.0 atmosphere is 100 ppb(v), the concentration of ClO in $\mu g/m^3$ is

   a. 4.07
   b. 5.14
   c. 31.8
   d. 77.4
   e. 209

2. In going from the low- to the mid-stratosphere, the air temperature:

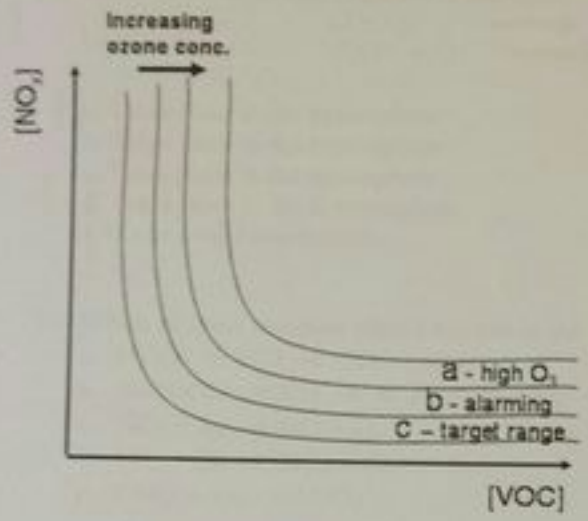
   a. increases, due primarily to heat release from the reaction $O + O_2 \rightarrow O_3$
   b. increases, due primarily to heat release from the reaction $O_3 + O \rightarrow 2O_2$
   c. increases, because NO_2, O_3 and ClO absorb high energy photons
   d. decreases, due primarily to heat absorption by the reaction $O_3 \rightarrow O_2 + O$
   e. decreases, due primarily to heat absorption by the reaction $2\,O_3 \rightarrow 3\,O_2$

3. Which of these reactions generates free radicals from a reservoir species in the troposphere?
   a. $OH + NO_2 + M \rightarrow HNO_3 + M$
   b. $O^* + H_2O \rightarrow 2\,OH$
   c. $HONO + h\nu \rightarrow NO + OH$
   d. $RCH_3 + OH \rightarrow RCH_2 + H_2O$
   e. $NO_2 + O_2 + M \rightarrow NO + O_3 + M$

4. In episodes of Photochemical Smog, most of the nitric oxide (NO) is oxidized to nitrogen dioxide by its reaction with

   a. peroxy free radicals $HO_2^{\bullet}$
   b. hydroxyl free radicals $HO^{\bullet}$
   c. PAN's
   d. free oxygen atoms
   e. hydrogen peroxide molecules H_2O_2

5. The diagram shows so called O_3-isopleths as a two variable diagram with NO_x and VOC as the variables. Which of the statements would you consider as true?
   I. a low concentration of VOC leads to high concentrations of tropospheric ozone
   II. a high concentration of NO_x could decrease the concentration of ozone in the troposphere
   III. neither VOC nor NO_x alone are suitable parameters to predict the level of ozone in the troposphere
   IV. the presence of both, NO_x and VOC leads to the highest concentrations of ozone in the troposphere
   V. the ozone concentration in the troposphere could be controlled by lowering the NO_x concentrations



a. answer I is right
b. answer I and II are right
c. answer III, IV and V are right
d. answer III and IV are right
e. not any of the answers is justified

6. The hydroxyl radical $^{\bullet}OH$ is one the radicals formed in the troposphere. According to its formation mechanism, its concentration will increase infinitely. Which reaction is responsible for its existence limitation in the atmosphere?

a. The reaction of $^{\bullet}OH$ with $^{\bullet}NO_2$ in the presence of a catalyst
b. The reaction of $^{\bullet}OH$ with oxygen in the presence of a UV light
c. The reaction of $^{\bullet}OH$ with an aldehyde in the presence of a catalyst
d. The reaction of $^{\bullet}OH$ with an aldehyde in the presence of a UV light
e. None of the above

7. Which group of chemicals is responsible of the formation of SMOG?

a. Nitrogen oxides, Volatile organic compounds and oxygen
b. Nitrogen dioxide, Volatile organic compounds and oxygen
c. Carbon dioxide, Methane and ozone
d. Ozone, Nitrogen oxides and Volatile organic compounds
e. None of the above

8. Consider the following compounds:
(i) NO_3
(ii) N_2O_3
(iii) HNO_3
(iv) HO_2NO_2
(v) NO

Which of the above compounds are considered as reservoir compounds in the destruction cycle of ozone?

a. (i) and (ii) only
b. (ii), (iii), and (iv)
c. (i), (iii), and (iv)
d. (i), (ii), (iii), and (iv)
e. all are true

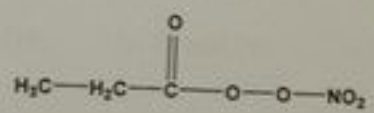
9. Consider the following sequence of reactions:

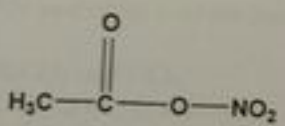
$$Cl + O_3 \longrightarrow ClO + O_2$$
$$ClO + O \longrightarrow Cl + O_2$$

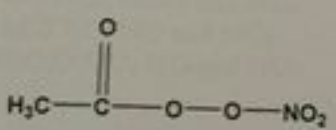
a. Takes place in the troposphere
b. Takes place in the stratosphere
c. Takes place in the mesosphere
d. Takes place in the thermosphere
e. Is not a valid mechanism

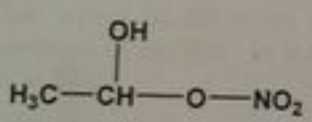
10. Which of these reactions plays a key role in the formation of Ozone in the troposphere?
a. $HOO\cdot + NO \rightarrow OH\cdot + NO_2$
b. $RCH_2OO\cdot + NO \rightarrow RCH_2O\cdot + NO_2$
c. $NO_2 + h\nu \rightarrow NO + O$
d. $NO + O_3 \rightarrow NO_2 + O_2$
e. $2\,NO + O_2 \rightarrow 2\,NO_2$

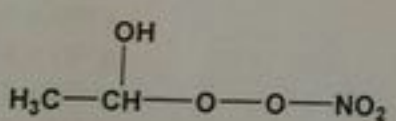
11. Which one is the correct structure of the Peroxyacetic Nitric Anhydride (PAN)?

a. 

b. 

c. 

d. 

e. 

12. The oxygen content of a fuel that is recommended in order to ensure complete combustion is about 2.7%. Consider a case where ethyl tertiary butyl ether (ETBE= $C_6H_{14}O$) is to be added to conventional gasoline (considered pure octane C_8H_{18}). What percentage of ETBE would be required to achieve the 2.7 mass % oxygen content in the mixture?

a. 22.4 %
b. 14.8 %
c. 54.1 %
d. 17.2 %
e. 5.3 %

13. Which of the following reactions are responsible of the formation of free hydroxyl radicals in the troposphere?

i. $O^* + H_2O \rightarrow 2\,OH\cdot$
ii. $HONO_4 + h\upsilon \rightarrow OH\cdot + \cdot NO_4$
iii. $RCH_3 + 2O_3 + H_2O \rightarrow RCHO + 4OH\cdot$
iv. $HO_2\cdot + NO \rightarrow NO_2 + OH\cdot$
v. $NO_3 + H_2O \rightarrow NO + 2OH\cdot$

a. (ii) and (v) b. (i) and (iv) c. (i), (iii) and (v) d. all except (v) e. all of them

14. PAN and nitric acid are reservoirs for the following radicals:

a. CH_3CH_2 and NO_2
b. HOO, CH_3CH_2 and NO_2
c. $CH_3C(O)O$, HOO and NO_2
d. $CH_3C(O)O$, HO and NO_2
e. $CH_3C(O)OO$, HO and NO_2

15. What would be the mean annual addition of methane (CH_4) in the atmosphere if the abundance of methane in the Earth's atmosphere changed from 700 ppb in 1750, to 1745 ppb in 1998?

a. 19.0×10^{16} g
b. 20.4×10^{14} g
c. 12.3×10^{6} t
d. 30.5×10^{8} t
e. 50.9×10^{14} g

16. Which of the following statements is False about ozone chemistry in the stratosphere?

If none of them is false pick answer (e).

(a) A possible mechanism for the photochemical dissociation of ozone involves ground state oxygen atom
(b) A steady-state concentration of ozone exists based on Chapman cycle
(c) There is a link between FREONS (CFCs) and the destruction of ozone
(d) Br free radicals catalyze the degradation of ozone
(e) all the above statements are true

17. Which of the statements below are WRONG for the species O^* in the stratosphere?

(i) reacts with NH_4OH to produce hydroxyl free radicals
(ii) reacts with Cl_2 to produce ClO
(iii) reacts with N_2O to form NO
(iv) is produced from the photochemical dissociation of ozone
(v) releases high energy when it is in the presence of CFC molecules
(vi) reacts with water to produce hydroxyl radicals

(a) all but (i) are wrong
(b) all are wrong
(c) (ii), (iii), and (iv) are wrong
(d) (i), (iii), and (vi) are wrong
(e) (i), (ii), and (v) are wrong

18. Which of the following statements is False about ozone chemistry in the stratosphere?

If none of them is false pick answer (e).

(a) A steady-state concentration of ozone exists based on Chapman cycle
(b) There is a link between FREONS (CFCs) and the destruction of ozone
(c) A possible mechanism for the photochemical dissociation of ozone involves ground state oxygen atom
(d) Br free radicals catalyze the degradation of ozone
(e) all the above statements are true

19. What is the predominant phosphate species in a contaminated river at pH = 6.00.
K_a values: $H_3PO_4 = 7.1 \times 10^{-3}$ $H_2PO_4^- = 6.3 \times 10^{-8}$ $HPO_4^{-2} = 4.2 \times 10^{-13}$

a) H_3PO_4
b) PO_4^{3-}
c) $H_2PO_4^-$
d) HPO_4^{2-}
e) All have same concentration.

20. What is the mass of water in 1 m^3 of air having a temperature of 30°C and a relative humidity of 70%? (Vapor pressure of water at 30°C = 31.824 mm Hg)

a. 51.7 g
b. 27.1 g
c. 21.2 g
d. 15.3 g
e. 9.2 g

21. Nitrogen monoxide plays the role of a catalyst for several reactions in the troposphere, of which is the oxidation of volatile hydrocarbons into aldehydes. Which of the following reactions is the correct NO-catalyzed net balanced reaction of the oxidation of butane?

a. $C_4H_{10} + 2O_2 + H_2O \rightarrow C_3H_7CHO + 4OH\bullet$
b. $C_4H_{10} + 2O_2 + 2NO \rightarrow C_3H_7CHO + 2NO_2 + H_2O$
c. $C_4H_{10} + 3/2\ O_2 \rightarrow C_3H_7CHO + 2OH\bullet$
d. $C_4H_{10} + 2NO \rightarrow C_3H_7CHO + 2NO_2$
e. $C_4H_{10} + 2O_2 + 2NO_2 \rightarrow C_3H_7CHO + 2NO_3 + H_2O$

22. Which of the following statements are false?

(i) A part of the carbon dioxide released in the atmosphere is dissolved in the oceans leading to the eutrophication.
(ii) The methane decay in the atmosphere is due to the reaction of this molecule with hydrogen molecules.
(iii) The use of fertile lands in agriculture increases the nitrification and denitrification which will lead to the increase in the N_2O production.
(iv) The photosynthesis is able to decrease the concentration of N_2O in the atmosphere.
(v) CFCs are degraded in water by photolysis.

a. (i), (ii), and (iv)
b. (i) and (iv)
c. (ii), (iii), and (v)
d. (i), (iii), and (v)
e. All of the above

23. Although greenhouse gases likely account for the problem of global warming, they are also responsible for making earth habitable. What would be the temperature on earth in the absence of the effects of carbon dioxide and water?

a. 45°C
b. 11°C
c. -18°C
d. -50°C
e. -273°C

24. Which of the following would indicate a warming in global average temperature?

a) An expansion of glaciers around the world.
b) A rise in sea level.
c) Earlier freeze dates for major lakes.
d) A and B.
e) B and C.

25. Which of the following would increase the albedo of the earth-atmosphere system?

a) Deforestation.
b) Glacial shrinking.
c) Reduction in snow cover.
d) All of the above.
e) None of the above.

26. A comparison of the trapping of heat by CO2 and CH4 is that

a) CH4 traps 21 times more heat in the atmosphere than does CO2
b) CO2 traps 21 times more heat in the atmosphere than does CH4
c) the same amount of heat is trapped by both CO2 and CH4
d) none of the above

27. The "atmospheric window":

I. allows part of Earth's back-radiation to escape into space
II. is a seasonal hole where stratospheric ozone is reduced to near zero
III. Is a gap in the atmospheric absorption spectrum, between the absorption dominated by water vapor and carbon dioxide

a) I only
b) II only
c) I and III
d) II and III
e) I, II, and III

28. The surface of the Earth reflects incoming solar energy. But not all surfaces reflect at the same rate. Match the correct reflection rates with the following landscapes:

x) dry grassland
y) conifer forest
z) ice

1) 80-95% reflection rate
2) 30-40% reflection rate
3) 10-15% reflection rate

	x	y	z
a)	3	1	2
b)	1	3	2
c)	2	3	1
d)	3	2	1
e)	1	2	3

29. The "atmospheric window" is important to the understanding of the greenhouse effect because it _____. The window is threatened by anthropogenic emissions of _____.

a) is transparent to radiation with a wavelength of about 10 microns; methane and CFCs
b) allows convective cooling of the troposphere; carbon dioxide
c) blocks UV-B radiation; ozone
d) is transparent to sunshine; nitrogen
e) blocks acid precipitation; sulfur dioxide

30. Which of the following is responsible for catching most of Earth's back-radiation to space?
a) water vapor
b) sulfur dioxide
c) particulate matter
d) carbon dioxide
e) CFCs

31. The production of nitric acid in the atmosphere is
a) dependent on the concentration of NO2 in day time
b) dependent on the concentration of NO2 in night time
c) dependent on the concentration of OH radicals in day time
d) dependent on the concentration of OH radicals in night time
e) Answers a, b and c

32. The production of sulfuric acid in the atmosphere can happen in
a) Homogeneous medium at the surface of solid particles
b) H_2O_2 rich atmosphere at $2 < pH < 5$
c) H_2O_2 rich atmosphere at $pH < 2$
d) H_2O_2 rich atmosphere at $pH > 5$
e) None of the above

33. The nitrate radical ($\bullet NO_3$) is formed in the troposphere during night-time due to the oxidation of $\bullet NO_2$ by O_3. Once in the troposphere, $\bullet NO_3$ can:

i. React with ammonium ions to form sulfuric acid
ii. React with $\bullet NO$ to produce $\bullet NO_2$
iii. Lead to the formation of N_2O_5 by reaction with $\bullet NO$
iv. Produce nitric acid (HNO_3) by reaction with aldehydes
v. Produce nitric acid (HNO_3) by reaction with alkanes

The correct answer is:
a. ii and iii
b. i, iii, and iv
c. ii, iv, and v
d. iii, iv, and v
e. iv, and v

34. In snow melting period, preferential elution of major precipitation anions occurs in the following order:

1. Sulfate > Nitrate > Chloride.
2. Nitrate > Sulfate >chloride.
3. Chloride > Sulfate > Nitrate
4. Chloride > Nitrate> Sulfate
5. None of the above

Good Luck!