The Use of Submarine and See-Saw Models in Teaching of Oxidation-Reduction Reactions

Mustafa Toprak*, Aslı Özkan, Şenol Alpat***

ABSTRACT

J.S.Brunner and D.Ausubel were psychologists, who provided important contributions in the field of science education. In this study, a verbal teaching was developed according to the principles of these psychologists. The topic on redox has been worked on and topic pattern was design in a scenario.

The reduction and oxidation reactions were taught by the models of submarine and seesaw, respectively. The results showed that the experimental group (A) was significantly more successful than the control group (B).

Keywords: Chemistry education, scenario, redox

ÖZET

J. S. Brunner ve D. Ausubel Fen bilimleri eğitimi alanında önemli katkılar sağlayan psikologlardır. Çalışmada sözlü öğretim bu psikologların prensiplerine göre geliştirildi. Redoks konusu üzerinde çalışıldı ve örnek konu senaryolaştırıldı.

İndirgenme ve yükseltgenme reaksiyonları denizaltı ve tahterevalli modelleri ile öğretildi. Sonuçlar, deneysel grubun (A) kontrol grubundan (B) önemli ölçüde daha başarılı olduğunu gösterdi.

Anahtar Kelimeler Kimya eğitimi, senaryo, redoks

1.Introduction

As an integral part of the scientific process, models are used in a variety of ways within the science classroom. Models are used by teachers to explain scientific phenomena .In addition, students usually make their own models of scientific phenomena to show their understanding [21]. Currently, in the science education reform movements the value of models and modelling has been increasingly recognized [1,10,18,19].

There are three aims in the science education, that is "learn science," "learning about science" and "learn to do science," and these purposes are supported by models and modelling. Recent science textbook contain many examples of scientific models, usually presenting these models as static facts. Despite the recent emphasis on constructivist teaching strategies, there aren't enough assignments inviting the students to actively construct, test or revise models in these books [7].

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Descriptive, explanatory or predictive approach can be used to characterize models. A large degree of "positive analogy" between model and target characterizes descriptive model [13]. An example is the heliocentric model, describing the orbits of the planets in our solar system. Through the implementation of a theory, an explanatory model may be designed. In the example, the concept of gravity, derived from Newtonian theory, may be used to design a model, which explains the movements of the planets. Moreover, the inclusion of theoretical notions in a model enables the formulation of predictions. For instance, Adams and Le Verier could predict the existence of the eighth planet, Uranus, on the basis of a model, which included the concept of gravity. Shortly after this prediction was made, Uranus was indeed identified by observation [6].

Modelling is a complex process involving many component activities; skill in respect of each of which has to be mastered. It must thus be assumed that it is only gradually acquired with any degree of competence. There are three epistemological commitments to produce models (Lehrer et all ,1994): First of all, a separation between phenomena and noumena, an appreciation that a representation may be of, but not identical with, that which is being represented. Secondly, the development and deployment of a system of formula elements might produce a representation. Thirdly, predictions are made based on simplified representations that lead to emergent behaviour to be identified [16].

With the recognized importance of models in science education comes the need for a theory of model-based learning and teaching. However, there is, to date, no coherent theory that outlines the cognitive processes involved in model-based learning, nor are there any coherent theories of how model-based teaching should be approached [12].

By models, Gobert et all are using the general definition put forth by Ingham and Gilbert [14]: a model is a simplified representation of a system, which concentrates attention on specific aspects of the system. Moreover, models enable aspects of the system i.e., objects, events or ideas which are either complex or on a different scale to that which is normally perceived or abstract to be rendered either visible or more readily visible [11].

In Turkey, the studies on the problem of education are concentrated mostly, on the argument on the models of teacher education. The ways and the techniques of teaching in the classroom has not been studied yet. For this reason, there isn't enough source of information on this basic subject. To solve this problem, the project on the setting up the science high schools was produced and the first science high school was established in Ankara in the year of 1964. In the United States a new program on science education was produced in 1960's.

The main idea of this program was based on Bruner's ideas, insight learning, learning and teaching of concept education[5]. This program was used in the science high schools in Turkey. The basic aim of this program was to bring up man of science. To reach this aim, these schools had to have intelligent students and be in cooperation with the universities in order to educate these students [9].

In the beginning, the curriculum of these schools was in harmony with the aim mentioned above. The percentage of the laboratory courses was much greater than the theoretical courses in the beginning. The students could see the realization of the theoretical principles in physics and chemistry during the experiments in the laboratories. Everything was in agreement with Bruner's ideas on insight learning. The programs and the learning techniques which were worked on in science high schools were wide spread to Anadolu high schools and to some of the general high schools and they were successful [4]. But the pressure of the university entrance examination (OSS) on the students and on the schools became an obstacle on the way to reach the aim of having man of science. The development of the curriculum to the area and the teaching techniques were stopped [22].

Another great contribution to the area of science education had come from a psychologist, D.Ausebell. According to Ausebell the most important part of learning was the meaning fullness of learning. It wasn't always possible to find meaning in insight learning. The greater part of the learning took place in verbal form. According to Ausebell [3], the most important factor in learning process was the student's accumulation of information. The new concepts and the principles were meaning full if they could be related to the old concepts and the principles which the student had learned in the past. If the new material was in contradiction to the learned material it was very hard for the student to understand and to comprehend the new material.

A great number of curriculum [17], teaching techniques [15, 8] were developed according to Bruner's and Ausebel's principles and the results of these studies were investigated by the scientists. The most important subject, which has worked on, was the misconceptions

[2,20] and the ways to get rid of them. These studies were mostly seen in the areas of science education and chemistry education following year of 1980.

As mentioned above, there hasn't been enough investigation on teaching techniques in the classroom in Turkey, so that we cannot reach any ample source of information about them. The aim of this study was to provide information for the following studies on this subject and to construct models of teaching for better understanding of the concepts and the topics by the students.

In this study, misconceptions about redox concepts were identified beforehand, and then a teaching approach to help students to overcome such misconceptions were developed. One of the best ways of doing this is to teach the unit by a modelling. The modelling should be developed with an effective scenario. As a result, a powerful module for overcoming students' misconceptions about redox concepts is shaped.

2. Method

Reduction and oxidation reactions (redox) redesigned in a scenario form which took place in the curriculum third classroom of high school. The students' participation was provided to the argument and the objects, models, concepts around them were used to facilitate their understanding of the topic. Samples in question were chosen from third classroom of high school students of Balıkesir, Bornova Mustafa Kemal and Bornova Suphi Koyuncuoğlu high schools. Two groups were formed: experimental group (A), control group (B). There were 42 students in each group. By this grouping technique, two groups of students were formed in each school.

In order to have equality between these groups the academic achievements of the students at the end of the year, and the opinion of their classroom teachers were taken into consideration. A test on the subjects of the last year was given to the students to determine their level of performance. According to the results of this test it was seen that these students were in the equal level of performance.

The chosen topic is taught by teacher's own style of teaching to the control group (B). The teacher taught the topic by the suggested technique to the experimental group (A). The suggested technique was based on the principles of Brunner and Ausubel. This technique was based on the conceptualization of the concepts in a true manner by using verbal teaching form. In this technique the oxidation and reduction phenomena were illustrated by the example of submarine (Figure 1) and the redox of reaction was illustrated by the example of seesaw (Figure 2 and 3) respectively.

In the explanation of the Figure 1 (submarine), the following questions are asked to the students:

- What is it called the ship that can dive to the water?
- Submarine
- Can you describe the submarine?
- It constitutes two boats which are one within another. When the space between two boats fills with water, the boat sinks. When the water is unloaded, the submarine moves out from the water.

In the explanation of the figure 2 (seesaw), the following questions are asked to the students:

- With how many people can be played?
- With two people
- How is the seesaw played?
- While one person on the one end of the seesaw goes down, the other goes up.
- What is the relationship about going up and down people who are at the either ends of the seesaw?
- The distance one goes down is the same with the other goes up.

The terminology and the concepts were explained by adopting them to the chosen model. The topics were taught to the experimental group (A) and to the control group (B) in the same week and in the same class hour. At the end of this application the level of performance of the students were determined by a test covering 20 questions. The statistical analysis was made in the department of computer

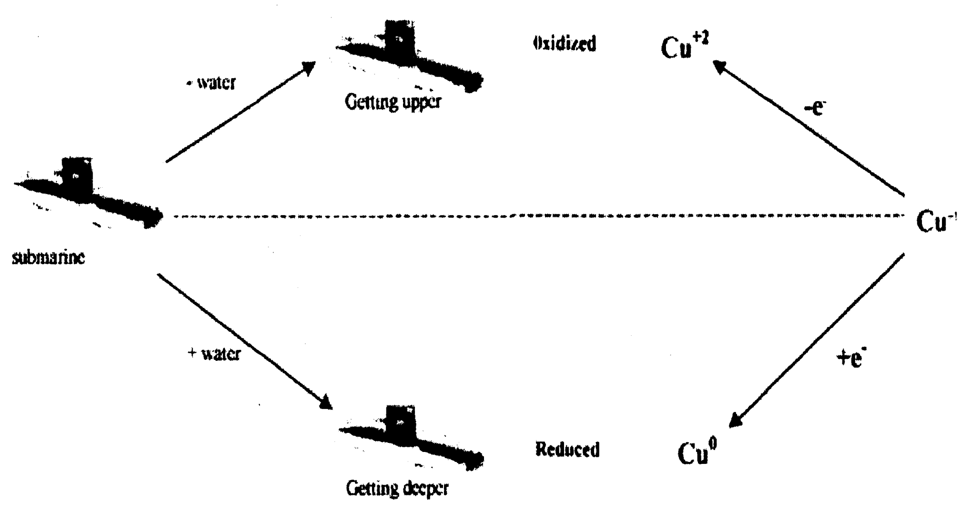

Figure 1. The model of submarine

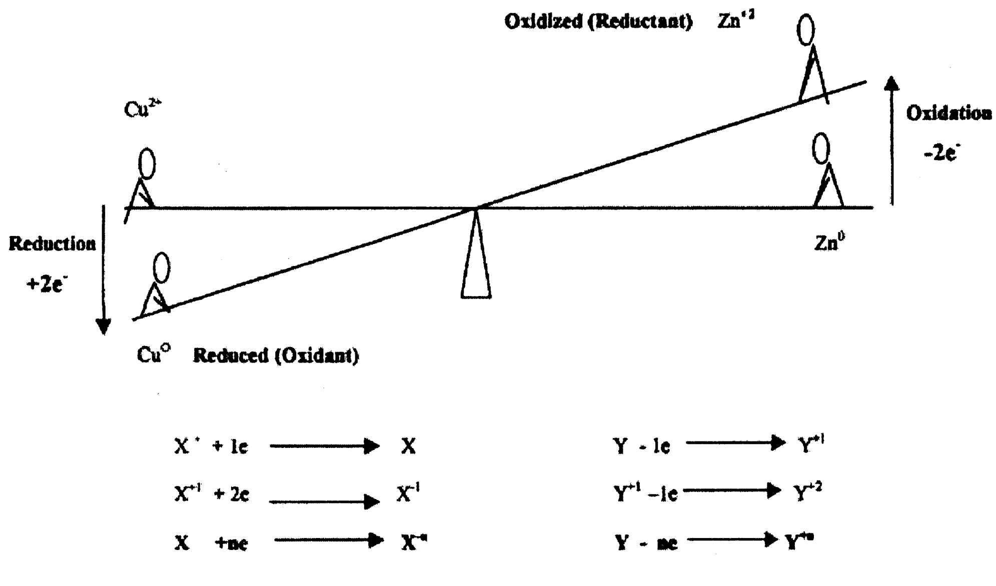

Figure 2. The model of see-saw

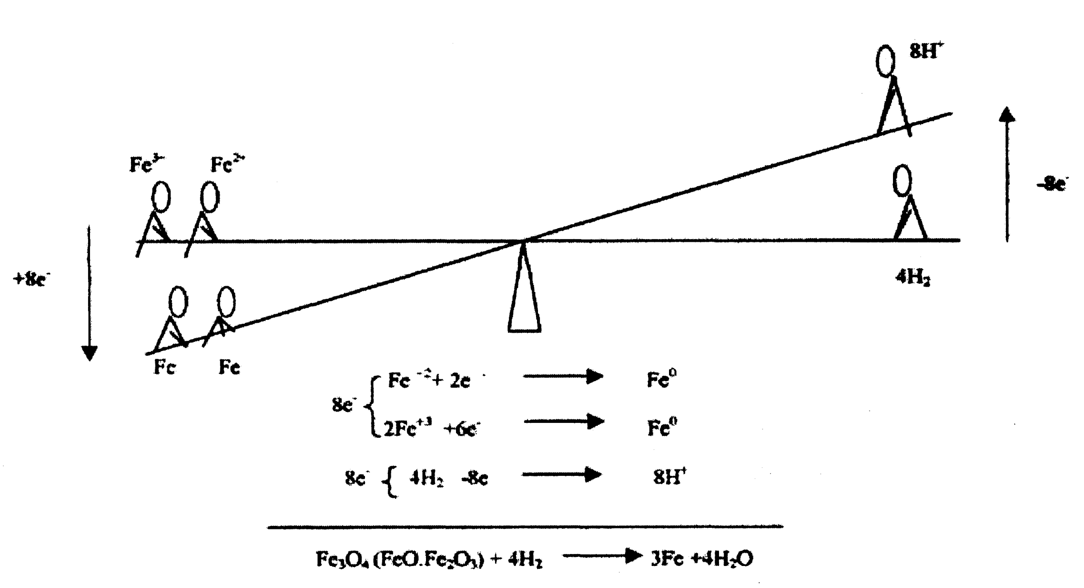

Figure3. **The illustration of the reaction between Fe_3O_4 and H_2 by see-saw model**

of computer engineering in Ege University. The results of this analysis are shown in Table-1.

3. Result and Discussion

The answers given to the questions on the test were analyzed one by one and the level of performance of the students in group A and B for every question in shown in table-1.The level of performance of both of the groups were approximately equal in defining reduction and oxidation. It seems that both group A and group B same answers related to the question of the meaning of reduction and oxidation. On the other hand, group A is more successful on balancing the redox reactions and separating half reactions. The experimental group (A) was significantly more successful in redox reactions which covered reduction and oxidation together. When t-test was applied between control (B) and experimental (A) groups of all school, we observed a statistical significant difference (for A and B of Balıkesir high school $t=5.201$, $P<0.05$, A and B of Bornova Mustafa Kemal High School $t=6.388$, $P<0.05$ and Bornova Suphi Koyuncuoglu high School t09.233, $P<0.05$). In addition, when experimental groups of two difference schools were compared, we didn't aoserved any difference ($t=1.382$, $P>0.05$). We conclude that group A is more successful. For example, the equalization of these reactions, the identification, of the education and the oxidation half reactions, the determination of the reduced and the oxidized species, the reductant and the oxidant reagents were understood easily with these scenarios.

The experimental group (A) was more successful in the topics as mentioned in the example. The mean of the performance points has shown that the experimental group (A) was significantly more successfully than the control group (B). The suggested technique was used in all the high schools and similar result were seen (Table-1).

Today, it is believe that the chemistry education has lost its effectiveness. It is also believed that the main reason of this lost is the pressure of the university entrance examination (OSS) on the students and on schools. The lost of quality in chemistry education can be easily detected in education system especially in the high schools as shown by the results of this study. However these results also show that this negative trend may be altered and the system may be cured.

Topics in the curriculum of the high schools would be redesigned; the courses would be taught in a scenario, the models, concepts around the students would be used to facilitate their understanding and learning of the course. Also it is believe that the ratio of the misconceptions maybe reduced.

Table 1. Analysis of Test Questions

Question number	High School	Group A (%)	Group B (%)	High School	Group A (%)	Group B (%)	High School	Group A (%)	Group B (%)
1	Balıkesir High School	77.3	23.8	Bornova Mustafa Kemal High School	82.6	73.9	Bornova Suphi Koyuncuoglu High School	79.2	62.8
2		100	4.8		91.3	69.6		95.4	70.4
3		100	100		91.3	52.2		94.2	60.3
4		100	9.5		95.7	95.7		95.2	85.2
5		100	57.1		47.8	39.1		80.3	45.2
6		100	81		82.6	43.5		91.2	46.4
7		90.9	61.9		100	65.2		95.4	70.5
8		100	95.5		78.3	65.2		89.3	72.3
9		95.5	85.7		91.3	52.2		93.3	55.6
10		100	71.4		39.1	26.1		75.4	35.2
11		100	95.5		100	95.7		96.6	97.2
12		95.5	76.2		91.3	52.2		94.6	62.2
13		100	81.8		73.9	26.1		86.2	65.2
14		100	72.7		82.6	78.3		96.4	62.3
15		59.1	4.8		95.7	34.8		66.2	40.2
16		86.4	4.8		91.3	26.1		80.2	35.2
17		85.7	77.3		39.1	21.7		75.5	45.2
18		100	100		87	52.2		100	62.2
19		68.2	0		82.6	60.9		90.2	55.6
20		63.6	4.8		95.7	39.1		70.6	70.2
Mean		**91.1**	**55.4**		**81.9**	**53.5**		**87.3**	**59.9**

A: Experimental group
B: Control group

a. 4. References

1. American Association for the Advancement of Science (1993) Benchmarks for Science Literacy (New York Oxford: *Oxford University* Press).
2. Anderson, B. (1986) *Science Education* 70, 549-563
3. Ausubel, D. (1968) *Educational Psychology,* Holf, Rinehart & Winston, New York
4. Ayas, A., Çepni, S &Akdeniz A.R. (1993) "Development of the Turkish secondry science curriculum,"Science Education, 77(4),433
5. Bruner, J. (1961) *Harward Educational Review* 31 (1) : 23
6. Drıel, J. H. V., Verloop, N. (1999) Teachers' knowledge of models and modelling in science. . *Int.J.Sci.Educ* 21, 11, 1141-1153
7. Driel, J.H.V and Verloop,N. (2002) Experienced teachers' knowledge of teaching and learning of models and modelling in science education. . *Int.J.Sci.Educ* , 24 12, 1255-1272
8. Fensham, P. J. (1992*) International of Science Education* 14 (5) 505-514
9. Foundatıon Law of Scıence Hıgh School, (1964) MEB, Ankara
10. Giere,R. (1991) *Understanding Scientific Reasoning* (Orlondo, FL:Holt,Rinehart, and Winston,Inc.).
11. Gılbert, J. (1995) The role of models and modelling in some narratives in science learning. *Presented at the Annual Meeting of the American Educational Research Association* , April 18-22. San Francisco, CA, USA
12. Gobert, J. D. (2000) Introduction to model-based teaching and learning in scienceeduca tion. . *Int.J.Sci.Educ.* 22, 9, 891-894
13. Hesse, M. B. (1996) *Models and Analogies in Science* (London : Sheen & Ward).
14. Ingham, A. M. and Gılbert, J. K. (1991) The use of analogue models by students of chemistry at higher education level. . *Int.J.Sci.Educ,* 13, 193-202
15. Johnstone, A.H. and Su, W.Y. (1994) *Education in Chemistry* 31 (3), 75-79
16. Justi, R. S. (2002) Modelling teachers' views on the nature of modelling and implications for the education of modellers. . *Int.J.Sci.Educ* 24, 4, 369-387
17. Middlecamp, C.H. and Kean, E. (1983) *Journal of Chemical Science Education* 10 (1), 111-120
18. National Research Council (1996) *National Science Education Standarts* (Washington, D.C.: National Academy Press).
19. National Science Board Comission on Precollege Education In Mathematics (1983) (Washington, DC:National Academy Press).
20. Novick, S. (1978) *J.Science Education* 62, 273-282
21. Treagust, D. F. (2002) Students'understanding of the role of scientific models in learning science. *Int.J.Sci.Educ.*, 24,4,357-368
22. Toprak, M. and Akboy, R. (1996) The proceeding in II. National Edu. Symp, Marmara Univ., Atatürk Educ. Fac., İstanbul

1. **Aşağıdakilerden hangileri yükseltgenmedir?**

   I. Bir metalin oksijenlebirleşmesi

   II. Bir atomun ya da iyonun elektron kazanması

   III. Bir metalin bileşik içindeki değerliğinin artması

   A) Yalnız I B) Yalnız II
   C) Yalnız III D) I ve III
   E) I, II ve III

2. **Aşağıda altı çizili maddelerden hangileri yükseltgenmiştir?**

   I. <u>Mg</u> + 1/2 $O_2 \rightarrow MgO$

   II. <u>C</u>O +1/2 $O_2 \rightarrow CO_2$

   III. <u>Fe</u>$_2O_3$+3CO $\rightarrow$ 2Fe+3CO_2

   A) Yalnız I B) Yalnız II
   C) Yalnız III D) I ve II
   E) I, II ve III

3. **Aşağıdaki tepkimelerden hansinde altı çizilen madde indirgenmiştir ?**

   A) <u>Zn</u> + 2HCl $\rightarrow ZnCl_2 + H_2$

   B) 2<u>Na</u> + 1/2 $O_2 \rightarrow Na_2O$

   C) <u>H_2</u> + CuO $\rightarrow$ Cu + H_2O

   D) 3<u>C</u>O + $Fe_2O_3 \rightarrow$ 2Fe + 3CO_2

   E) <u>N_2</u> + 3$H_2 \rightarrow 2NH_3$

4. **Aşağıdaki tepkimelerden hangisi bir yükseltgenme – indirgenme tepkimesidir ?**

   A) $MgCl_{2(k)} \rightarrow Mg^{+2} + 2Cl^-$

   B) Fe^{+2}+2$OH^- \rightarrow Fe(OH)_{2(k)}$

   C) $Mg_{(k)}$+$Fe^{+2} \rightarrow Mg^{+2} + Fe_{(k)}$

   D) $HCl_{(g)}$+$H_2O_{(s)} \rightarrow H_3O^+ + Cl^-$

   E) CN^-+$H_2O_{(s)} \rightarrow HCN + OH^-$

5. $KClO_3 + SO_2 + H_2O \rightarrow KCl + H_2SO_4$

   Tepkimesinde indirgen ve yükseltgen elementler hangi seçenekte doğru verilmiştir?

<u>İndirgen</u>	<u>Yükseltgen</u>
A) K	S
B) S	K
C) Cl	S
D) S	Cl
E) Cl	O

6. Redoks denklemleri denkleştirilirken

   I. Atom sayıları denkliği

   II. İyon yükleri denkliği

   III . Elektron alış-veriş denkliği

   işlemlerinden hangileri gerçekleşmelidir ?

   A) Yalnız II B) I ve II
   C) I ve III D) II ve III
   E) I, II ve III

7. Bir redoks tepkimesi için,

   I. Elektron veren madde indirgendir.

   II. Elektron alan madde indirgenir.

   III. Yükseltgen = İndirgen ve İndirgenen=Yükseltgenendir.

   yargılarından hangileri doğrudur ?

   A) Yalnız I B) Yalnız III
   C) I ve II D) II ve III
   E) I, II ve III

8. **Aşağıdaki tepkimelerden hangi si bir redoks tepkimesi <u>değildir</u> ?**

   A) $Br_2 \rightarrow Br^- + BrO_3^-$

   B) P+HNO_3+$H_2O \rightarrow H_3PO_4$+NO

   C) H_2 + 1/2 $O_2 \rightarrow H_2O$

   D) Al + $OH^- \rightarrow AlO_2^- + H_2$

E) $HCl + NaOH \rightarrow NaCl + H_2O$

9. $SO_3^{-2} + IO_3^{-} \rightarrow I_2 + SO_4^{-2}$

Asit ortamda oluşan redoks tepkimesi için aşağıdakilerden hangisi <u>yanlıştır</u> ?

A) IO_3^- yükseltgen maddedir.

B) SO_3^{-2} indirgen maddedir.

C) SO_3^{-2} iyonundaki S, $2e^-$ alarak SO_4^{-2} iyonunu oluşturur.

D) İndirgenme yarı tepkimesi $2IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$ dur.

E) Yükseltgenme yarı tepkimesi $SO_3^{-2} + H_2O \rightarrow SO_4^{-2} + 2H^+ + 2e^-$

10. $2X + 6Cl^- + 16H^+ \rightarrow 2Cr^{+3} + 3Cl_2 + 8H_2O$

tepkimesinde X ile simgelenen bileşiğin yapısındaki metalin değerliği kaçtır ?

A) +2 B) +3 C) +4 D) +6 E) +7

11. **X_3YO_4 de Y nin değerliği kaçtır ?($_8O$, $_1X$)**

A) 1 B) 2 C) 3 D) 4 E) 5

12. $CuS + HNO_3 \rightarrow CuSO_4 + NO + H_2O$

tepkimesi en küçük tam-sayılarla denkleştirildiğinde H_2O nun katsayısı kaç olur ?

A) 2 B) 3 C) 4 D) 5 E) 6

13. $P + HNO_3 + H_2O \rightarrow H_3PO_4 + NO$

Yukarıdaki tepkimeye göre 0,93 gram P kullanıldığında oluşan NO gazının NK daki hacmi kaç litre olur ? (P = 31)

A) 1,12 B) 2,24 C) 5,6 D) 6,72 E) 11,2

14. $Sn_{(k)} + HNO_{3(suda)} \rightarrow SnO_{2(suda)} + NO_{2(g)} + H_2O_{(s)}$

Yukarıdaki tepkime için aşağıdakilerden hangisi doğrudur ?

A) Homojen tepkimedir.

B) 0,1 mol Sn tepkimeye girdiğinde NK da 2,24 litre NO_2 gazı oluşur.

C) 1 mol Sn 4 mol elektron verir.

D) HNO_3 indirgendir.

E) Suyun katsayısı 1 dir.

15. Bazik ortamda $Cr(OH)_4^-$ ile ClO^- den CrO_4^{-2} ve Cl^- oluşuyor.

Bu olayda yükseltgenme yarı tep-kimesini denkleşmiş denklemi aşağıdakilerden hangisidir ?

A) $Cr(OH)_4^- \rightarrow CrO_4^{-2} + 3e^-$

B) $Cr(OH)_4^- + 3e^- \rightarrow CrO_4^{-2} + 2OH^-$

C) $Cr(OH)_4^- + 4OH^- \rightarrow CrO_4^{-2} + 3e^- + 4H_2O$

D) $ClO^- + 2e^- \rightarrow Cl^-$

E) $ClO^- + 2e^- + H_2O \rightarrow Cl^- + 2OH^-$

16. Asidik ortamda P ile NO_3^- den PO_4^{-3} ve NO oluşuyor.

Bu olayda yükseltgenme yarı tepkimesinin denklemi aşağıdakilerden hangisidir ?

A) $P \rightarrow PO_4^{-3} + 5e^-$

B) $4H_2O + P \rightarrow PO_4^{-3} + 5e^- + 8H^+$

C) $4H_2O + P \rightarrow PO_4^{-3} + 8H^+$

D) $4H^+ + NO_3^{-1} \rightarrow NO + 2H_2O$

E) $4H^+ + NO_3^{-1} + 3e^- \rightarrow NO + 2H_2O$

17. $Au + NO_3^- + Cl^- \rightarrow AuCl_4^- + NO$
Asitli ortamda oluşan tepkime en küçük tamsayılarla denkleştirilirse H^+ nın katsayısı kaç olur ?
A) 1 B) 2 C) 3 D) 4 E) 5

18. Asidik ortamda gerçekleşen
$ClO^- + MnO_4^- \rightarrow MnO_2 + ClO_3^-$
Tepkimesiyle ilgili aşağıdakilerden hangisi <u>yanlıştır</u> ?

A) Denkleşmiş yükseltgenme yarı tepkimesi,
$ClO^- + 2H_2O \rightarrow ClO_3^- + 4H^+$
şeklindedir.

B) MnO_4^- deki Mn yükseltgendir.

C) ClO^- deki Cl elektron verir.

D) ClO^- indirgendir.

E) İndirgenme yarı tepkimesi
$4H^+ + MnO_4^- + 3 \rightarrow MnO_2 + 2H_2O$

19. Bazik ortamda gerçekleşen
$ClO_3^- + Mn^{+2} \rightarrow MnO_2 + Cl^-$
tepkimesindeki maddelerin katsayıları en küçük tamsayılı olacak biçimde denkleştirilirse suyun katsayısı kaç olur ?

A) 1 B) 2 C) 3 D) 4 E) 5

20. Asitli ortamda Fe^{+2} ve MnO_4^- iyonları Fe^{+3} ve Mn^{+2} oluşturur.

20 ml 1 M MnO_4^- çözeltisi en fazla kaç gram Fe^{+2} iyonunu yükseltger ? (Fe = 56)
A) 0,28 B) 1,2
C)1,4 D) 2,8 E) 5,6