

**Reviewer's Comment**

Ephemerides for unperturbed elliptic motion are generally computed from the exact solution of the equations of motion via Kepler's equation. In his book on orbit determination (1), Dubyago describes a method of computing ephemerides based directly on numerical integration of the unperturbed two-body equations of motion. Shchigolev's paper discusses a computational method for obtaining an approximate solution to the two-body equations of motion which is much simpler than the other two methods.

Shchigolev replaces the factor  $1/r^3$  in the equations of motion by its expected value. He proposes several different methods for determining this expected value.

This substitution linearizes and decouples the equations of motion, permitting an analytic solution to be obtained. Several refinements of this technique are discussed and ap-

plied to minor planet orbits.

The methods used by Shchigolev would probably be most useful for computing search ephemerides for minor planets and comets where great precision is not required. They permit the rapid calculation of an ephemeris by a desk calculator when a digital computer is not available. His methods have also been applied to space vehicle orbit transfer computations (2,3).

—FREDERICK T. SMITH  
The RAND Corporation

1 Dubyago, A. D., *The Determination of Orbits* (The Macmillan Company, New York, 1961); English translation.

2 Smith, F. T., "A discussion of a midcourse guidance technique for space vehicles," RAND Corp. Research Memo. RM-2581 (October 3, 1960).

3 Hutcheson, J. H. and Smith, F. T., "An orbital control process for a 24-hour communication satellite," RAND Corp. Research Memo. RM-2809-NASA (October 1961).

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**Digest of Translated Russian Literature**

The following abstracts have been selected by the Editor from translated Russian journals supplied by the indicated societies and organizations, whose cooperation is gratefully acknowledged. Information concerning subscriptions to the publications may be obtained from these societies and organizations. Note: Volumes and numbers given are those of the English translations, not of the original Russian.

**JOURNAL OF PHYSICAL CHEMISTRY (Zhurnal Fizicheskoi Khimii).** Published by The Chemical Society, London.

Volume 35, number 10, October 1961.

**Thermodynamic Functions of Monatomic and Diatomic Gases Over a Wide Temperature Range. III. Nitrogen Atoms, Nitrogen Molecules, and Nitric Oxide in the Ideal State up to 20,000°K.** V. S. Yungman, L. V. Gurvich, V. A. Kvividze, E. A. Prozorovskii, and N. P. Ritschcheva, pp. 1073-1077.

The present paper describes the calculation of the thermodynamic functions ( $\Phi_T^*$ ,  $S_T^0$ ,  $H_T^0 - H_0^0$ ) of N, N<sub>2</sub>, and NO in the ideal state at 1 atm pressure between 293.15° and 20,000°K, by methods described previously. Equilibrium constants  $K_p$  for dissociation into monatomic gases have also been calculated for N<sub>2</sub> and NO.

*Summary:*

1 A selection has been made of the most reliable values of the molecular constants of N, N<sub>2</sub>, and NO necessary for the accurate calculation of the thermodynamic functions of these gases.

2 The thermodynamic functions of the gases N, N<sub>2</sub>, and NO in the ideal state at 1 atm pressure between 293.15° and 20,000°K have been calculated by direct summation over the energy levels on the BESM of the USSR Academy of Sciences.

3 The dissociation constants of N<sub>2</sub> and NO between 293.15° and 20,000°K have been calculated.

**Isotope-Exchange Method for Measuring Vapor Pressures and Diffusion Coefficients. III. Treatment of Experimental Data.** V. I. Lozgachev, pp. 1084-1090.

*Summary:* A procedure has been developed for the determination of the constants in the solution of the diffusion equation for isotope exchange through the gaseous phase in  $\gamma$ - and  $\beta$ -radiation measurements. Equations have been found which make it possible to find from one experimental curve, plotted from the start of the process up to the steady state, the rate of evaporation  $n_0$ , the diffusion coefficient  $D$ , and the thickness of the exchange layer  $\delta$ . A computation formula is proposed as well as a method for the experimental determination of the condensation coefficient  $\alpha$ .

**Theory of Electrical Transport. II. Multicomponent Metallic Systems.** D. K. Belashchenko and B. S. Bokshstein, pp. 1099-1101.

The previous paper in this series applied the thermodynamics of irreversible processes to the diffusion of the components of a binary metallic alloy when a direct current is passed through it. It is useful to generalize these results to multicomponent metallic systems. The present paper concerns a three-component system, assuming for simplicity that the partial volumes of the components are equal.

**Oxidation-Reduction Kinetics of Hydrogen, Oxygen, and a Stoichiometric Oxygen-Hydrogen Mixture at a Platinum Electrode in Electrolyte Solutions.** K. I. Rozental' and V. I. Veselovskii, pp. 1114-1118.

It has been shown in our laboratories that the oxidizing and reducing components (hydroxyl radicals, hydrogen atoms, O<sub>2</sub>, H<sub>2</sub>, and H<sub>2</sub>O<sub>2</sub> molecules), resulting from the radiolysis of water, produce characteristic electrochemical processes at the electrode. When this occurs, the electrode potential may acquire any value between the potentials of the hydrogen and oxygen electrodes, depending on the properties of the electrode metal, its reaction with the radiolysis products, its adsorption capacity with respect to them, and the rate of ionization of the given substance at the electrode. Therefore, an investigation of the kinetics of the electrochemical interaction between oxygen and hydrogen on metal electrodes in electrolyte solutions acquires an additional interest.

Earlier investigations show that the catalysis of the oxidation of oxygen-hydrogen mixtures in electrolyte solutions is determined by the electrochemical properties of the catalyst and the electrode potential.

In our studies (by anodic polarography) of the oxidation and reduction of gaseous H<sub>2</sub>-O<sub>2</sub> mixtures on a platinum electrode in electrolyte solutions, it has been found that the effectiveness of the process depends, to a large extent, upon the potential of the electrode, nature of the anion, and the pH of the solution.

The method employed here makes it possible to measure directly, over a wide range of potentials applied by polarization of the Pt electrode (0-1.6 v), the true rates of the oxidation of

hydrogen and reduction of oxygen from the consumption of  $H_2$  and  $O_2$  ( $\text{cm}^3\text{hr}^{-1}$ ); the rates have also been calculated from the reduction and oxidation currents.

*Summary:*

1 A relation has been found between the potential of a Pt electrode in 1  $N$   $H_2SO_4$ , 1  $N$   $HClO_4$ , and 1  $N$  KOH solutions and the rate of  $H_2$  oxidation,  $O_2$  reduction, and the reaction between  $H_2$  and  $O_2$  at the electrode. The rates were determined from the consumption of gas and the quantity of electricity used.

2 It has been shown that, in contrast to polarographic data, the rate of  $H_2$  oxidation in acid solutions at a passivated electrode (0.9–1.4 v) may be fairly high (amounting to 50–30% of the limiting rate). The rate depends on the activity of oxygen chemisorbed on the platinum. It has been suggested that oxidation of  $H_2$  at an electrode occurs via reaction with chemisorbed oxygen, evolved either electrochemically or supplied from the gas phase (in the case of the oxygen-hydrogen mixture).

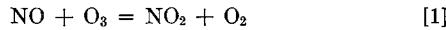
3 It has been found that the limiting rate of  $O_2$  reduction in acid is twice as high as in alkali. In all the solutions investigated, the rates calculated from the current are close to those measured from the consumption of the gas, if it is assumed that the reaction product is water.

4 It has been shown that the reaction rate of the oxygen-hydrogen mixture depends essentially on the potential of the Pt electrode, the nature of the anion, and the pH of the solution. At steady-state potentials ( $i = 0$ ) the rate in 1  $N$   $H_2SO_4$  ( $\varphi_0 = 0.6$ –0.8 v) is close to the limiting value and nearly twice as high as in 1  $N$   $HClO_4$  ( $\varphi_0 = 0.8$  v) and three times as high as in 1  $N$  KOH ( $\varphi = 0.8$  v).

5 The principle of the independent course of  $H_2$  ionization and  $O_2$  reduction in the reaction of the oxygen-hydrogen gas, proposed earlier, is valid with some limitations (1  $N$  KOH, to some extent 1  $N$   $HClO_4$ ). In many cases, interaction of these two processes is observed, leading either to an increase in the overall rate ( $H_2SO_4$ ) or to a suppression of the  $H_2$  ionization ( $HClO_4$ ).

**Oxidation of Microconcentrations of Nitric Oxide to Nitrogen Peroxide by Ozone in a Gas Flow. II**, M. T. Borok, pp. 1123–1125.

It has been found previously that, at 45° and above, microconcentrations of NO and  $O_3$  react according to the equation



where the ratio  $q = [O_3]/[NO]$  of the initial concentrations of the reactants necessary for complete oxidation of NO to  $NO_2$  in the gas flow (for the range 0–20  $\text{cm}^3\text{m}^{-3}$  NO) is given by

$$q = 1 + \frac{A}{[NO]} \quad [2]$$

in which

$$A = \frac{v\varphi}{k_{NO}V} \quad [3]$$

where  $v$  is the volume rate of flow of the gas in the reaction zone of volume  $V$ ,  $k_{NO}$  the rate constant for the oxidation  $NO \rightarrow NO_2$  by ozone, and  $\varphi$  an approximately constant factor, the mean value of which can be taken as 6.5 when  $q = 2$ –8 and  $\alpha = 0.999$ . When the temperature of the gas in the reaction zone is ~60° and  $V/v = 1.3$  sec, the factor  $A = 18.2 \pm 0.2 \text{ m}^3\text{cm}^{-3}$ .

The correctness of the results was checked by means of an automatic photocolorimetric analyzer calibrated on the basis of Eq. [2] with respect to the NO oxidized to  $NO_2$  by ozone under the specified conditions. The test consisted in measuring out a certain amount of  $NO_2$  by weighing on an analytical balance and then determining the microconcentration of  $NO_2$  in the air by means of this analyzer.

*Summary:*

1 The validity of the condition found for complete oxidation of microconcentrations of NO to  $NO_2$  by ozone ( $q = 1 + 18.2 \cdot [NO]^{-1}$  at  $T \simeq 60^\circ$  and  $\tau = 1.3$  sec) is confirmed by a) the agreement between the readings of an analyzer which measures the concentrations of NO (after its oxidation to  $NO_2$ ) and  $NO_2$  added in measured quantities to the gaseous mixture by independent methods; and b) the practical identity of values for the oxidation rate constant calculated from the present results and from those of experiments carried out by Johnston and Harvey under different conditions.

2 It has been established that ozone can completely oxidize microconcentrations of NO to  $NO_2$  at normal temperatures in a current of mixed gases containing macroconcentrations of other components which are readily oxidizable by ozone. In a current of coke oven gas or of a nitrogen-ethylene mixture, practically complete oxidation of microconcentrations of NO to  $NO_2$  by ozone is achieved when the ratio of the reactant concentrations is  $q \simeq 1 + 37.5 [NO]^{-1}$ , where  $[NO]$  is expressed in  $\text{cm}^3\text{m}^{-3}$ .

**Heats of Combustion of Some Bicyclanes**, M. P. Kozina, S. M. Skuratov, S. M. Shtekher, I. E. Sosnina, and M. B. Turov-Polyak, pp. 1144–1146.

The heats of combustion of all organic compounds cannot be measured because of their enormous number. Consequently, it is necessary to find methods of calculation for predicting the heat of combustion of any compound on the basis of a relatively small number of reliable experimental data. The existing experimentally determined heats of combustion of various classes of hydrocarbons have been used to set up methods for the calculation of the heats of combustion of all the hydrocarbons in each class. However, there are no experimental data for many, even relatively simple, hydrocarbon groups.

The present paper describes a determination of the heats of combustion of some bicyclic hydrocarbons containing 5-, 6-, and 7-membered rings. These quantities have not been determined hitherto, apart from the work of Wise and co-workers on hydrocarbons containing two 6-membered rings, for which the calorimetric technique used and the error in the results are not indicated.

*Summary:* The heats of combustion of dicyclopentyl, bis(cyclopentyl)methane, cyclopentylcyclohexane, cyclopentylcycloheptane, dicycloheptyl, and trans- $\beta$ -methyldecalin have been determined at 25°. A method has been proposed for the calculation of the heats of combustion of various bicyclanes from the heats of combustion of the monocyclanes and the heats of formation of the bicyclanes from the monocyclanes. A relation has been given for the calculation of the heats of combustion of decalins alkyl-substituted in the  $\beta$  position. The heats of isomerization of bicyclanes to trans-decalin or trans- $\beta$ -methyldecalin have been calculated.

**Effect of Active Species in Combustion Products on Flammability Limits in a Turbulent Flow**, S. M. Kogarko, V. V. Mikheev, and V. Ya. Basevich, pp. 1156–1160.

It has been found that enhanced initial concentrations of active species (free oxygen and hydrogen atoms and hydroxyl radicals) improve (accelerate) very substantially self-ignition, stabilization of a flame, and its rate of propagation in a turbulent flow. This is probably due to the increased reaction rates in the initial stages of burning.

This paper deals with the effect of active species, forming in the products of combustion of hydrogen and hydrocarbons, on the flammability limits in a turbulent flow.

*Summary:*

1 On increasing the initial concentrations of active species, a broadening of the flammability limits is observed with mixtures of hydrocarbons or hydrogen with air.

2 The broadening of the limits in the presence of active species occurs when spark, pilot-flame, and heated-body ignition is used.

3 Changing the concentration of active species by the introduction of variously coated surfaces affects the flammability limits in conformity with the coefficients of recombination of the species.

**Reaction Kinetics and Explosion in the Nitrogen Dioxide-Butane Systems**, S. K. Ermakova, V. M. Cherednichenko, and S. Ya. Pshezhetskii, pp. 1161–1164.

Many papers have been published on the reaction of nitrogen dioxide with hydrocarbons, but comparatively little work has been done on the kinetic aspects. An investigation has recently been made of the kinetics of the reaction between  $NO_2$  and methane, but no kinetic study has been made with higher hydrocarbons. Yet the kinetics of these processes could give much valuable information on the mechanism of the reaction of  $NO_2$  with hydrocarbons. A comparison of methane with the higher hydrocarbons is particularly important, since for the latter the reaction involves cleavage of the hydrocarbon molecule.

The kinetics of the reaction of  $NO_2$  with butane can be determined at lower temperatures than in the case of methane, some of the complications associated with decomposition of the

$\text{NO}_2$  being thereby avoided. The critical conditions for explosion in these systems and their correlation with the kinetic laws of the slow reaction are also of obvious interest but have not been studied. The present paper reports some results on reaction kinetics and explosion in the  $\text{NO}_2$ -butane system.

*Summary:*

1 Measurements have been made of the kinetics of the reaction between  $\text{NO}_2$  and n-butane. The overall order of the reaction is 2.1, the order with respect to butane being 0.7, and with respect to  $\text{NO}_2$  1.4. The activation energy of the reaction is 30 kcal mole<sup>-1</sup>.

2 The critical conditions for explosion in a mixture of these substances have been determined. The effective activation energy of the pre-explosion reaction calculated from the explosion limit on the basis of the thermal theory of explosion is 28 kcal mole<sup>-1</sup>. This indicates that the critical conditions for explosion are consistent with the kinetic laws of the pre-explosion reaction.

**Volume 35, number 11, November 1961.**

**Thermodynamics of Critical and Hypercritical Phenomena in Solutions.** V. K. Semenchenko, pp. 1210-1215.

1 An analysis has been made of the possible types of phase transitions in solutions from the point of view of thermodynamic stability. The concepts of adiabatic and isodynamic stability coefficients have been introduced. Examination of the behavior of the adiabatic stability coefficients shows that they have finite minima at the critical point and in the hypercritical region, whereas the isodynamic coefficients have finite minima in the hypercritical region but tend to zero at the critical point.

2 The statistical significance of the stability coefficients has been elucidated; they are inversely proportional to fluctuations, which thus have a fundamental role in critical and hypercritical transitions.

3 An analysis has been made of phases with limiting stability, and it has been shown that second-order transitions are possible only in the presence of such phases.

4 The relation between the kinetic coefficients (thermal diffusivity, diffusion coefficient, etc.) and the stability coefficients has been elucidated and hence the characteristics of approach to critical equilibrium.

**Oxidation-Reduction Kinetics of Hydrogen, Oxygen, and a Stoichiometric Oxygen-Hydrogen Mixture at a Gold Electrode in Normal Sulphuric Acid.** K. I. Rozenthal' and V. I. Veselovskii, pp. 1227-1230.

The object of the present investigation was to use the method worked out earlier to measure the rates of the oxidation of hydrogen, the reduction of oxygen, and the reaction between these gases at a gold electrode in 1*N*  $\text{H}_2\text{SO}_4$  as a function of the potential, and to compare them with the corresponding rates at a platinum electrode under the same experimental conditions.

*Summary:*

1 Measurements of the amount of gas which disappears in a given time, taking into account the quantity of electricity thereby consumed, have been used to find the variation with potential of the rates of oxidation of hydrogen, reduction of oxygen, and interaction of these gases at "active" and "passive" gold electrodes in 1*N*  $\text{H}_2\text{SO}_4$  (the latter electrode had been heated in oxygen at 850°).

2 The two types of gold electrodes have been shown to differ substantially in their behavior toward the ionization of hydrogen. Whereas at the "active" electrode the velocity of this reaction is close to that measured at a platinum electrode under the same conditions, the reaction does not take place at all at the "passive" electrode.

3 The limiting rate of reduction of oxygen to water at an "active" electrode has been found to be about double that at a "passive" electrode. This result can be explained on the assumption that the net rate of reduction of oxygen at solid electrodes depends not only on the quantity of oxygen supplied to the electrode but also on the ability of the particular metal to adsorb and ionize oxygen.

4 The rate of "combustion" of a stoichiometric oxygen-hydrogen mixture at an "active" electrode at the steady-state potential (0.4-0.5 v) has been found to be practically equal to that obtained at a platinum electrode. The assumption that the ionization of hydrogen and the reduction of oxygen occur independently is justified at potentials more cathodic than the steady-state value. At more anodic potentials these two

processes affect one another, and the overall reaction velocity is increased.

5 The velocity of the reaction of the oxygen-hydrogen mixture at the "passive" electrode at the steady-state potential (0.75-0.85 v) is very low. At more cathodic potentials, only the reduction of oxygen to water takes place, in good agreement with polarographic results.

**Second Virial Coefficient of Vapors and Their Mixtures. III. The Acetone-Chloroform System.** Sh. D. Zaalishvili and L. E. Kolysko, pp. 1291-1292.

The acetone-chloroform system is a typical example of a system with a maximum boiling point. In order to reproduce data on the liquid-vapor equilibrium more exactly, it is necessary to know the second virial coefficients.

*Summary:*

1 The compressibilities have been measured, and the second virial coefficients calculated, for mixtures of acetone and chloroform vapors, the data being tabulated for 60°, 70°, 80°, and 90°.

2 The experimental results for these mixtures are well reproduced by the equation derived from statistical mechanics.

3 The data on the second virial coefficients for the acetone-chloroform system have been used to calculate fugacities in the vapor phase. The deviations from the partial pressures are considerable, amounting to 3-10%.

**Internal Stresses Arising During Cathodic Occlusion of Hydrogen by Metals.** A. T. Sanzharovskii and O. S. Popova, pp. 1308-1310.

The occlusion of hydrogen by metals often produces internal stresses in the latter which may be large. These stresses have sometimes been considered the main cause of both the decrease in strength and the appearance of brittleness on saturation with hydrogen. Measurement of the internal stresses and their dependence on the electrochemical conditions is therefore of considerable practical and theoretical interest.

*Summary:* A method based on the use of bimetal strips is suggested for the calculation of the internal stresses produced by hydrogen in metals during cathodic polarization.

**Volume 35, number 12, December 1961.**

**Passage of a Gaseous Ozone Detonation Through Capillaries.** V. V. Yastrebov and O. I. Kozunenko, pp. 1319-1321.

It has been shown that ozone differs from most other explosive gases in its high sensitivity to detonation and the ease of propagation of flames. This is confirmed by the present study of the passage of the ozone detonation through capillary tubes.

The passage of gas detonations through capillaries and narrow openings has been little studied. A critical review has been given by Shaulov. The experiments have normally been carried out in such a way that the gas is ignited in an open part of the apparatus, connected to the atmosphere. The pressure in the burnt gas does not then increase significantly and therefore has no influence on the phenomenon of detonation transfer. In the present work we have studied the other limiting case where the detonation of a gas (ozone) in a closed vessel is transferred along a thin capillary tube into another closed vessel containing ozone.

*Summary:* The conditions for the passage of a gaseous ozone detonation through 20 cm capillary tubes in a closed apparatus at low gas pressures, up to 300 mm Hg, have been studied. The detonation is transferred through the capillary only at gas pressures above a certain boundary value ( $p_b$ ). For given apparatus dimensions, the plot of  $p_b$  against the reciprocal of the capillary diameter is approximately linear. The transfer of the detonation through the capillary involves detonation waves along the capillary at  $\sim 1800 \text{ m sec}^{-1}$ . At 264 mm Hg the detonation wave passes unhindered through a 0.799 mm diameter capillary. At lower pressures the detonation wave breaks down on leaving the capillary and is reformed after a slight delay.

**Physical Properties of Tungstates. III. Magnetic Properties.** R. D. Shapovalova, V. I. Belova, A. V. Zalesskii, and Ya. I. Gerasimov, pp. 1340-1342.

The magnetic susceptibilities of tungstates of Mg, Ca, Sr, Ba, Zn, Cd, Pb, Mn, Fe, Co, Ni, and Cu were determined by the methods of Gouy and Sucksmith. Measurements were made at several values of the magnetic field strength; the susceptibility did not depend on field strength, showing that ferromagnetic

impurities are absent. The results obtained at room temperature (293°K) are given in Table 1.

Table 1 Magnetic susceptibility of tungstates

Compound	Mag. susceptibility, $\chi \times 10^6$		Mag. susceptibility $\chi \times 10^6$	
	Per gram	Molar	Compound	Per gram
MgWO <sub>4</sub>	-0.110	-30.0	FeWO <sub>4</sub>	+40.3
CaWO <sub>4</sub>	-0.121	-35.0	CoWO <sub>4</sub>	+33.3
SrWO <sub>4</sub>	-0.135	-45.3		+35.5
BaWO <sub>4</sub>	-0.149	-57.4	NiWO <sub>4</sub>	+11.2
ZnWO <sub>4</sub>	-0.125	-39.2		+13.4
CdWO <sub>4</sub>	-0.138	-49.4	CuWO <sub>4</sub>	+3.12
PbWO <sub>4</sub>	-0.133	-60.5		+2.85
	+35.6	+10,782		
MnWO <sub>4</sub>	+40.6	+12,296		

#### Summary:

1 The magnetic susceptibilities of twelve tungstates have been measured.

2 The value of the diamagnetic susceptibility of the WO<sub>4</sub><sup>2-</sup> ion has been found from the susceptibilities of the diamagnetic tungstates of Mg, Ca, Sr, Ba, Zn, Cd, and Pb. The mean value,  $-(28.4 \pm 1.9) \times 10^{-6}$ , agrees well with that found previously.

3 The magnetic susceptibilities of the paramagnetic tungstates of Mn, Fe, Co, Ni, and Cu obey the Curie-Weiss law in the range 290°-700°K.

**Thermodynamic Theory of Surface Tension**, B. V. Belogurov, pp. 1342-1346.

Current theories of the surface properties of crystals follow two essentially quite different lines: metals and nonmetallic crystals (principally crystals of alkali metal halides) are treated independently.

Such an approach cannot be justified on methodological grounds. The correct procedure is to examine first the general laws governing the surface properties of materials and then take into account, if necessary, the characteristic properties of the given bond type among the species in the crystals.

The general basis of the thermodynamics of surfaces, treated as interfaces between phases, was established in the fundamental investigations of Gibbs; these, however, require further development in order to obtain relations for theoretical calculations of surface tension. The present paper deals with the surface layer elements, which can be extended to materials comprising various types of species.

#### Summary:

1 A thermodynamic theory of the surface tension of elements is proposed, in which the surface tension is represented as a function of the average activation energy for self-diffusion. Relations derived from the theory are in agreement with experimental data and satisfy the limiting values at  $T = 0^\circ\text{K}$  and  $T = T_{cr}$ .

2 It has been shown that the temperature coefficient of the surface tension of pure elements is negative (except possibly at the temperatures of first-order phase transitions which are accompanied by change in the coordination of the species constituting the element). The experimentally observed positive values of  $d\sigma/dT$  for copper and Armco iron must be ascribed to the effect of impurities.

3 The fundamental principles of the theory may be applied to materials comprising species of several kinds.

**Problem of Ordered and Disordered Energy in Chemical Thermodynamics. I**, N. I. Kobozev, pp. 1351-1355.

The problem of order and disorder in energy has been examined in relation to chemical thermodynamics, and a vector interpretation of thermodynamic functions is suggested.

**Problem of Ordered and Disordered Energy in Chemical Thermodynamics. II. Equilibrium Between Vector and Brownian Forms of Energy in Chemical Thermodynamics**, N. I. Kobozev, pp. 1355-1358.

A vector interpretation of thermodynamic functions has been used to obtain new relations among them:

$$\frac{T\Delta S}{\Delta F} = \gamma e^{-\epsilon/RT}$$

$$\Delta F = \frac{\Delta U}{1 + \gamma e^{-\epsilon/RT}}$$

$$\Delta S = \frac{\Delta U}{T} \frac{\gamma}{\gamma + e^{\epsilon/RT}}$$

where  $\epsilon$  is the expenditure of energy on the thermal disturbance of the quantum-ordered form of internal energy for reactions of the type  $\Delta U < 0$ ,  $\Delta S < 0$ ,  $\Delta F < 0$ . The Nernst-Planck theorem has been deduced from these relations. A subsequent paper will describe the application of the new relations to different classes of reactions.

**Hypersonic and Ultrasonic Properties of Pyridine-Benzene Solutions**, M. S. Tunin and M. I. Shakhparyonov, pp. 1337-1378.

In order to explain the molecular nature of hypersonic relaxation processes, it is of interest to study their dependence on solution composition. This has not been done so far. Measurements of the rate of propagation of hypersonic and ultrasonic waves, viscosity, and absorption coefficient for sound in benzene-pyridine solutions at 25° are reported below. The rate of propagation of hypersonic waves  $v$  was determined optically from the fine structure of the Rayleigh line of scattered light. The method and experimental conditions have been described. The exposure time for photographing the fine structure of the Rayleigh line ( $\lambda = 4358 \text{ \AA}$ ) did not exceed 20 min. The refractive indices of benzene and pyridine are almost the same. Therefore the contribution to the central component of the Rayleigh triplet from scattering due to concentration fluctuations is not substantial.

**Summary:** The rate of propagation of ultrasonic and hypersonic waves, the absorption coefficient for sound, and viscosity in pyridine-benzene solutions at 25° have been studied. Parameters have been calculated which characterize the acoustic relaxation process in these solutions.

**Volume 36, number 1, January 1962.**

This issue of the Russian Journal of Physical Chemistry includes a series of papers dealing with a physicochemical interpretation of the most important biological laws. During recent years problems associated with life have attracted the attention of a wide range of scientists working not only in the fields of biochemistry and biology but also in those of physics, chemistry, physical chemistry, and cybernetics. Considerable successes have been achieved by research aimed at correlating the biological functions of macromolecular compounds such as nucleoproteins with their physicochemical properties. On the other hand, the thermodynamic and kinetic aspects of the problem of the origin and evolution of life still remain obscure and urgently require elaboration. The editors have considered it useful to include a few papers of a speculative character as a basis for discussion. The first paper is to a large extent general; subsequent original papers (by V. K. Semenchenko, N. I. Kobozev, and V. M. Andreev) set out the views of the authors on the thermodynamics and the kinetics of biological processes and on the possibilities of steady states in different systems. Individual statements are no doubt open to question, and the views of the authors on several problems do not coincide; however, the papers do not contain the elements of a controversy. The editors consider the confrontation of opinions to be useful, and hope to be able to publish further papers in this interesting field in the future.

It is proposed to publish in a subsequent issue a paper by N. M. Emanuel' dealing with the kinetics of the growth of tumors and quantitative aspects of the cancer-inhibiting action of chemotherapeutic agents.

**Thermodynamics of Irreversible Processes and the Problems of Biogenesis**, L. A. Nikolaev, pp. 1-7.

**Thermodynamics of Protoplasm**, V. K. Semenchenko, pp. 7-11.

**Thermodynamic Factors in the Kinetics of the Autocatalytic Reproduction and Multiplication of Simple and Complex Prototypes. I**, N. I. Kobozev, pp. 11-17.

The present paper analyzes the role of thermodynamic factors in the kinetics of multiplication, especially in the transition from the limited multiplication of organized structures to the un-

limited growth of disordered formations. This provides the basis for the physicochemical treatment of pathological growth processes.

*Summary:*

1 The kinetics of multiplication is limited by three main factors—exhaustion of the substrate, equilibrium, and species destruction—and can be represented by a general equation differing only in the size of the limiting growth  $\Phi_0$ .

2 The fact that the equation for ordinary autocatalysis (Robertson's) is applicable to the process of multiplication does not define the nature of the factor which restricts multiplication and does not indicate that the process is irreversible. The equation to Pearl's "logistic" curve is a particular case of the equation derived in the present paper.

3 Cases of multiplication are possible in which, with increase in the equilibrium constant, normal restricted growth passes into unrestricted pathological growth, which develops according to an exponential law.

4 A consecutive process of multiplication of complex prototypes (cells, for example), accompanied by their destruction, passes in the limit into an equilibrium type of growth, restricted by the thermodynamic potential of the final state.

5 In contrast to the growth of the physicochemical systems, which are not bound by limiting dimensions or a shape, the limiting size and form of biological objects can be ensured only by equilibrium growth. This requires, however, that biological growth should be regulated with the aid of information and feedback, which can be effected only when the process is reversible.

**Thermodynamic Factors in the Kinetics of Autocatalytic Reproduction and Multiplication of Simple and Complex Prototypes. II. Thermodynamic Conditions for Normal and Abnormal Multiplication and Growth, N. I. Kobozev, pp. 17-22.**

A higher entropy of complex prototypes (cells) must produce an increase in the rate and the limiting value of their multiplication. When the entropy is sufficiently large, cell multiplication or growth becomes in the nature of an unrestricted process of exponential increase. This pattern may be regarded as a physicochemical representation of the genesis and growth of malignant neoplasms. The concept of the "biological entropy" of a cell is introduced, and a principle is given together with approximate methods for its calculation based on Shannon's equation (employed in information theory). The published properties of cancer cells show that their biological entropy is in fact higher than with normal cells, in conformity with the theory developed here. The hypothesis is put forward that, by analogy with a chemical reaction, a barrier must be surmounted in the process of cell degeneration, but this is negentropy, not an energy barrier, and corresponds to a diminished entropy, which limits the process of degeneration in its initial stages.

**Angular Mean Values in the Lattice Theory of Liquids, Yu. V. Gurikov, pp. 52-56.**

The lattice theory of liquids, while possessing neither the rigor nor the generality of the method of integral equations, does give, at the present time at any rate, better quantitative results, especially at high densities of the material.

In addition to the hypothesis that a liquid has a quasi-crystalline structure, the following assumptions are made: 1) a molecule in a cell is subject on the average to a spherically symmetrical force field produced by the remaining molecules in the liquid; 2) the potential energy of a molecule in a cell can be obtained by finding the unweighted mean w.r.t., the angular coordinates of this molecule, which is equivalent to the hypothesis of the independent motion of molecules in neighboring cells and tends to increase the repulsive contribution to the thermodynamic properties of a liquid; 3) the potential energy of a molecule in a cell is calculated on the assumption that neighboring molecules are located in their mean positions, i.e., at the centers of the corresponding cells, but this takes no account of many configurations in which molecules are very close together in a liquid; 4) interaction between molecules which are not nearest neighbors can be neglected. The original theory of Lennard-Jones and Devonshire is to some extent inconsistent, in that the calculation of the free volume takes account only of the interaction with the first shell of nearest neighbors, while the zero-point energy (when all the molecules are located at the centers of their cells) is calculated exactly. Hirschfelder and his collaborators based their calculations on three shells. The present calculations of the corresponding integrals are based on only two shells.

The present paper proposes a stricter correlation between the motion of molecules in neighboring cells. Assumption 3 is retained in order to simplify the analysis, although formally, following an idea of Kirkwood's, the theory can easily be generalized to include the effect of the vibration of molecules in neighboring cells.

*Summary:*

1 Refinement of the free-volume theory of Lennard-Jones and Devonshire by an approximate consideration of the coordination (correlation) between the motion of molecules in neighboring cells on the whole improves the agreement between theory and experiment, and in several respects (vapor pressure, critical pressure) it is not inferior to the hole version of the theory.

2 The correlation effect cannot explain completely the thermodynamic properties of a liquid.

In order to work out a quantitative theory of the liquid state on the basis of the cell model, the vibration of neighboring molecules and the possibility of multiple occupation of cells must be taken into account as well as the correlation.

**Electrical Synthesis of Ozone. IV. Effect of Discharge Intensity, Yu. V. Filippov and Yu. M. Emel'yanov, pp. 89-93.**

The intensity (power) of the discharge is one of the principal parameters governing the electrical synthesis of ozone. It has a decisive influence on the efficiency of the ozonizer and the energy yield and concentration of the ozone obtained. The literature on this question is very scanty. The majority of papers deal with the effect on the electrical synthesis of ozone, not of the discharge intensity itself, but of the parameters on which it largely depends (current, voltage, frequency, etc.).

Becker derived an empirical equation for the relation between ozone concentration and the discharge intensity:

$$x = \frac{U}{k + \epsilon_0 v}$$

where  $U$  is the discharge intensity,  $\epsilon$  the energy consumed per unit quantity of ozone formed,  $k$  a constant, and  $v$  the flow rate (in units of volume) of the oxygen through the ozonizer. Becker showed that the frequency and voltage do not play a specific role in the electrical synthesis of ozone; they affect the formation of ozone only in so far as they change the intensity of the discharge. It has been observed that increase in the discharge intensity above a certain limit leads to a decrease in the concentration of the ozone.

Starke, who studied the effect of current frequency, also came to the conclusion that the change in the concentration of ozone obtained when the frequency is raised to 10,000 cps is due solely to a change in the discharge intensity.

Brenner studied the electrical synthesis of ozone at various discharge intensities and a constant flow rate of oxygen through the ozonizer. In his experiments the intensity was varied from 1 to 34 w and the oxygen flow rate was 6 liter  $h^{-1}$ . He concluded that increase in the discharge intensity leads to an increase of the ozone concentration up to a certain limit.

In 1936, from an examination of the energetics and activation in a discharge, Vasil'ev et al. showed that, regardless of the type of electrical discharge, the chemical reactions in it obey the usual laws of chemical kinetics when the time  $t$  in the relevant kinetic equations is replaced by the ratio of the discharge intensity  $U$  to the flow rate of the gas  $v$ . The factor  $U/v$ , which has the dimensions  $wh\ liter^{-1}$ , represents the quantity of energy per unit volume of the gas which has passed through the ozonizer. We have shown that it reflects the kinetics of reactions in a flow (for ideal displacement) and that it satisfies the principle of proportionality of the kinetic constants to the specific discharge intensity (per unit volume of the reaction zone). However, as shown, Becker's and our experiments show that increase in the intensity may lead to a decrease in the ozone concentration. This is evidence that the effect of the discharge intensity of the electrical synthesis of ozone is not fully explained by the kinetic equation of Vasil'ev et al.

*Summary:* The variation of the ozone concentration with the power dissipated in the electrical synthesis is not fully taken into account by the introduction of the factor  $U/v$  into the kinetic equations. Increase in the discharge intensity (power) results in an increase of the gas temperature in the ozonizer reactions and hence an increase of the ozone decomposition rate.

The temperature drops in the ozonizer electrode walls, in the reaction-zone gas and between the electrode and the cooling

liquid have been calculated. The kinetic curves for the synthesis of ozone in an ozonizer with a 1 mm discharge gap, calculated allowing for the temperature variation in the reaction zone, are in good agreement with experiment. The importance of the cooling of the electrodes in the electrical synthesis of ozone is noted.

**Effect of High Energy  $\gamma$  Radiation on Wetting Properties of Minerals**, A. K. Kikoin, B. P. Afanas'yev, G. V. Buresh, and A. E. Buzynov, p. 120.

**PHYSICS OF METALS AND METALLOGRAPHY**  
(*Fizika Metallov i Metallovedenie*). Published by Pergamon Institute, New York.

Volume 12, number 2, 1961.

**Motion of a Quasi-Particle With an Arbitrary Dispersion Law in a Weakly Homogeneous Magnetic Field**, V. M. Nabutorskii and A. A. Slutskin, pp. 10-13.

The classic motion of a particle is studied with an arbitrary law of dispersion in a weakly homogeneous magnetic field. Equations of motion which allow for crossdrift have been deduced for the "orbit center." These equations have been integrated to the first approximation which is nonvanishing through the parameter of triviality. A number of particular cases have been analyzed, including that of the quadratic anisotropic law of dispersion. A study has been made of motion on a "corrugated cylinder"-type surface. It seems that at a certain field configuration a particle will complete an oscillatory movement in an  $r$  space.

**Hydrogen Embrittlement in Alloys of Iron with Chromium and Its Dependence on the Temperature and Rate of Testing**, V. A. Yagunova and K. V. Popov, pp. 14-19.

An investigation has been made of the temperature and rate dependence of the cross-sectional reduction of area in alloys of iron with 0.5 to 5% chromium in temperature ranges from  $-196^{\circ}$  to  $+20^{\circ}$  and four rates of extension from 200 to 0.045 mm/min. The temperature minimum for ductility has been found, which is displaced when the rate of deformation is changed. The existence of the minimum is attributed to the formation of additional obstacles to slip which are stable in this temperature range, in the form of stationary dislocations filled with an atmosphere of hydrogen atoms.

*Conclusions:*

1 The ductility of alloys of iron with chromium containing hydrogen in solid solution has a minimum in the temperature range from  $-60^{\circ}$  to  $-100^{\circ}$ , which is displaced to the lower limit of this range when the rate of deformation is reduced.

2 The minimum can be attributed to the emergence of additional barriers to the movement of dislocations. These barriers are sessile dislocations which have been stopped by clouds of hydrogen atoms. Disappearance of the barriers may be the result of the displacement of previously stopped dislocations together with their surrounding hydrogen clouds.

**Influence of Electrolytic Hydrogen on Microhardness in Certain Metals**, V. V. Kuznetsov, N. I. Konstantinov, and V. A. Frolov, pp. 82-86.

This work presents the results of the experimental determination of change of microhardness in Armco-iron, nickel, and tantalum under the influence of electrolytic hydrogen.

1 Measurement has been made of the changes in the microhardness of iron, nickel, and tantalum under the influence of electrolytic hydrogen. It has been found that the curves for the changes in microhardness in grain centers and on the boundaries pass through a maximum both on the side of the metal turned to the electrolyte and on the opposite side. When the metals are polarized in electrolytes with additions of hydrogenation stimulators—arsenic or selenium—after a drop, a rise is observed on the curves for the change in microhardness. The reason has been put forward for this effect.

2 The change in microhardness has been measured in iron saturated with hydrogen in the course of annealing.

**Mechanism of the Formation of a White Zone in the Surface Layer of Mild Steel Under Dry Friction**, I. Ye. Brainin and N. N. Seleznev, pp. 87-90.

Under dry friction, specimens of mild steel are enriched by an active surface layer containing up to 1.6% carbon and  $50-200\text{-}\mu$  thick. During prolonged tests the surface layer, which is enriched with carbon and chromium, becomes heated to above  $A_{c1}$  point and, of course, as soon as the machine is stopped, it becomes quenched due to the rapid cooling. This causes the formation of a light zone the structure of which consists of martensite, austenite, and cementite. Due to the displacement of the ferrite the active surface layer is not then enriched by carbon.

**Problem of the Energy Losses of Fast Non-Relativistic Electrons in Metals**, A. A. Rukhadze and V. P. Silin, pp. 111-113.

Volume 12, number 3, 1961.

**Role of Stresses in the Formation of Hairline Cracks**, I. Ye. Brainin, pp. 16-19.

Objections are raised to Mes'kin's hypothesis regarding the mechanism of formation of hairline cracks. A scheme is given for the influence of stresses and molecular hydrogen on the pileup of dislocations. It has been found that the pressure of molecular hydrogen against the walls of a "gap" formed by dislocation pileup may cause the hydrogen atoms to gather toward the top in the elastically extended crystal lattice cells of ferrite. The parallel process of the association of atoms into molecules causes high stresses in the lattice and embrittlement of the ferrite, as a result of which the "gap" develops into a hairline crack under the pressure of molecular hydrogen.

*Conclusions:*

1 Hairline cracks in steel are formed under the simultaneous influence of molecular hydrogen in the "gaps" in mosaic structure blocks, where there is accumulation of groups of dislocations, and the elastic tensile stresses which develop as a result of this at the apex of such "gaps." Because of this there is local hydrogen enrichment as a result of uphill diffusion, with subsequent embrittlement of the metal due to the recombination of the atoms into hydrogen molecules.

2 Where there is a normal concentration of hydrogen in a steel ( $5-8 \text{ cm}^3/100 \text{ g}$ ) the main role of supplementary stresses, apart from their mechanical action, consists in that they cause the segregation of vacancies, pileup of dislocations, and stimulate the conditions of uphill hydrogen diffusion.

**Structure and Physical and Mechanical Properties of TiC-WC-Co Alloys**, V. F. Funke, V. S. Panov, and S. I. Yudkovskii, pp. 70-75.

Information has been obtained regarding the dependence of volume resistivity in two- and three-phase alloys of TiC-WC-Co on cobalt content and heat treatment. The figures obtained indicate that the cobalt is soluble in the TiC phase and that for alloys where  $\text{TiC}/\text{WC} = 0.19$  this solubility is around 2% at  $1200^{\circ}$ . In the presence of the structurally free tungsten carbide the titanium phase is subjected to tensile stresses.

The dependence of tensile stress in bending and of hardness on cobalt content has been found for the alloys where  $\text{TiC}/\text{WC} = 0.19$  and 1.765.

**Influence of Tin on the Oxidation of Titanium**, D. I. Lainer and Ye. N. Slesareva, pp. 82-88.

The purpose of the present work was to investigate the influence of tin to the amount of 4 at. % (9 wt %) on the oxidation of titanium in the temperature range  $700-1000^{\circ}$ , and to get further information necessary for an understanding of the mechanism of oxidation.

**Thermodynamics of the Irreversible Processes of Elastic Deformation**, N. S. Fastov, pp. 114-120.

This article considers the irreversible processes which are due to the final rate of deformation and the final rate of thermally homogeneous heating. In the case of quasi-stationary movements (at low external perturbation frequencies) the thermodynamic homologs will be of the same shape for the homogeneous and nonhomogeneous internal energies. The rate of growth of entropy has been calculated. Using the concrete example of ferro-nickel alloys, the percentage difference has been found between adiabatic and isothermal viscosity.

**Problem of Distinguishing the Broadening Effects in Powder Lines by the Harmonic Analysis of First- and Second-Order Reflections**, B. I. Smirnov, pp. 132-135.

**Volume 12, number 5, 1961.**

**Optical Properties of a Gyroelectric Medium II. Propagation of Flat Waves in a Gyroelectric Medium**, G. A. Bolotin and A. V. Sokolov, pp. 3-6.

On the basis of the invariant representation for the permittivity tensor of a gyroelectric medium, which was obtained previously, the problem of the propagation of flat waves in this medium has been studied, and formulas have been derived for the refraction vector and for the eigenfield vectors of a light wave.

**Temperature Dependence of Magnetostriction in Electrical Engineering Steels**, F. N. Dunayev and M. K. Kuznetsova, pp. 24-27.

An experimental study has been made of the dependence of magnetostriction in polycrystalline specimens of electrical engineering steel, containing up to 4.10% silicon, on temperature in the range 20-750°C. From the results, it has been found that certain qualitative conclusions can be drawn regarding the dependence of the magnetostriction constant on temperature and composition.

The temperature dependence of magnetostriction has been studied in considerable detail for a number of ferromagnetic metals and alloys. Up to the present time, however, very little study has been devoted to the temperature dependence of magnetostriction in such important magnetic materials as the ferrosilicon alloys. The present work puts forward the main results of the investigation of the temperature dependence of magnetostriction in electrical engineering steels with varying silicon contents. Certain of our results coincide qualitatively with the figures, but there is considerable difference in the mechanisms revealed. Besides this, another interpretation is given to the experimental data obtained.

*Conclusions:*

1 The temperature dependence curves for saturation magnetization in all ferrosilicon alloys with silicon content up to 4.10% have peaks which shift to lower temperatures as the silicon content increases.

2 The temperature dependence saturation magnetostriction is nonlinear in the temperature range from the  $\lambda_s$  maximum to Curie point in all the alloys investigated.

3 Analysis of the magnetostriction curves for polycrystalline specimens provides the basis for qualitative comparative conclusions regarding the dependence of magnetostriction constants on the temperature and composition of the alloys. From our measurements it follows that: a) magnetostriction constant  $\lambda_{100}$  increases when the temperature is raised from 20 to 420°C, in the whole range of compositions investigated; b) magnetostriction constant  $\lambda_{111}$  is negative in all ferrosilicon alloys containing up to 4.10% silicon and with increasing temperature it diminishes monotonically to its absolute value; c) in the range of compositions investigated  $\lambda_{111}$  diminishes monotonically with increasing silicon content, and  $\lambda_{100}$  appears to have a maximum of about 2.5% silicon.

**Investigation of Atomic Interaction in Solid Solutions Titanium-Zirconium-Tin**, V. V. Glazova, N. N. Kurnakov and A. R. Lyaschenko, pp. 28-31.

The atomic interaction characteristics have been studied in solid solutions on the system titanium-zirconium-tin in the field of concentrations adjacent to the titanium corner.

**Investigation of the Propagation of Cracks in Steel**, V. M. Finkel' and I. O. Katkin, pp. 99-105.

A cinematographic method has been developed for the study of crack propagation in metals. A study has been made of the kinetics of crack growth in the course of dynamic fracture in steel and of the influence of various factors on this: applied load, height of drop, dimensions, shape of notch, etc.

**Mechanism of Plastic Deformation During Creep in Alloys of Aluminum With Magnesium**, V. A. Pavlov, M. G. Gaidukov and V. V. Mel'nikova, pp. 113-119.

Creep and stress relaxation have been studied in Al-Mg alloys for deformation rates ranging from  $10^{-4}$  to  $10^{-11}$  sec $^{-1}$ . With rising temperature and diminishing rate of deformation shear deformation is replaced by diffusion ductility.

*Conclusions:* These results indicate that, as in alloys of nickel with copper, in aluminum-magnesium alloys the mechanism of plastic deformation in the conditions of creep and stress relaxation is subject to a change when the conditions of deformation are

varied. As the temperature increases and the deforming stresses are reduced, diffusion processes begin to play an ever increasing role.

At relatively low temperatures and high deforming stresses it is the shear mechanism which is in operation.

In high temperature regions and low stresses the diffusion mechanism prevails.

In the intermediate range of temperatures and stresses shear plastic deformation is combined with relaxation processes.

The alloying of aluminum with magnesium causes extension of the stress region where diffusion processes play an important part in plastic deformation. Expansion of the region of diffusion plastic deformation takes place as a result of the increase in resistance to the development of shear deformation and the greater reduction in activation energy with increasing stress in the alloys under the diffusion mechanism of plastic deformation.

**Magnetic Susceptibility of Liquid Metal Alloys**, E. L. Dubinin, O. A. Yesin, and N. A. Vatolin, pp. 131-133.

At the present time only a small number of works have been published on the determination of magnetic susceptibility ( $\chi$ ) of metallic fusions at high temperatures. But even the amount of experimental material available permits a number of interesting conclusions regarding the structure of binary fusions. The fact is, that in para- and diamagnetic materials the  $\chi$  value is determined by the amount of free electrons causing the magnetism. Variation in this quantity, which is possible where there is considerable interaction between neighboring atoms, may influence magnetic moment and through it, the  $\chi$  value.

In this work the magnetic susceptibility isotherms of Fe-Mn, Fe-P and Mn-Si fusions were studied.

**Mechanism of the Bond Between a Metal Coating and Its Base**, A. I. Vitkin and G. A. Kokorin, pp. 154-157.

**Volume 12, number 6, 1961.**

**Optical Properties of a Gyroelectric Medium. III. The Problem of Reflection for a Gyroelectric Medium**, G. A. Bolotin and A. V. Sokolov, pp. 1-8.

The solution to the boundary problem of light reflection can be found by using the equations for the eigenvectors of the electric field strength of light waves propagated in a gyroelectric medium. Formulas have been derived which define the dependence of the reflective power of the specimen and Kerr effect characteristics on the orientation of the gyrotropy axis. The results can be used when considering the problems of studying domain structure of ferromagnetics by means of the magneto-optic Kerr effect.

**Mechanical Properties of Sodium in the Range of Low Temperature Polymorphic Transformations**, I. A. Gindin, B. G. Lazarev, Ya. D. Starodubov, and M. B. Lazareva, pp. 59-64.

The mechanical properties of sodium have been determined in tension in the temperature range 1.6-300°K. As in lithium, in sodium a number of features have been revealed in the mechanical properties, due to the presence of low temperature polymorphic transformations: increased ductility and uniformity of deformation, strain-hardening, and microhardness. These peculiarities are regarded as "mechanical" criteria for the presence of a low temperature polymorphic state.

**Regions of Coherent Rearrangement in a Crystal Lattice on Phase Transformations in Solids**, V. I. Arkharov, pp. 65-71.

A general scheme is given for calculating the shape and dimensions in the coherent rearrangement region in a lattice, i.e., the region in which atom displacements do not exceed the normal space between atoms.

**Anomaly in the Ductility of Two-Phase Brasses**, A. A. Presnyakov and G. V. Starikova, pp. 84-88.

Investigation of two-phase  $\alpha + \beta$  and  $\beta + \gamma$  brasses has provided information regarding the ductility anomalies which develop in these alloys as a result of phase transformations. The temperature dependence of electrical resistivity and of the lattice parameter have also been measured. On the basis of the results an attempt has been made to show that these anomalies are the result of eutectoid decomposition.

*Conclusions:*

1 The  $\beta'$  phase which exists below 460°C in brass is a metastable one which is very stable in ordinary circumstances.

2 On heating and deformation the  $\beta'$  phase is probably transformed, first to an intermediate and then to a metastable

$\beta_n$  phase. This exists in a narrow temperature range, and then it disintegrates into a mixture of  $\alpha + \gamma$  phases, and then a stable high temperature  $\beta$  phase is formed from this mixture.

3 All these transformations are quite clearly revealed on the temperature curve of elongation, as also of electrical resistivity and lattice constant.

4 The method used for determination of ductility in certain cases enables one to obtain figures which can be used to study phase transformations in the alloys.

**Effect of Hydrogen and Oxygen on the Mechanical Properties and Structure of the Titanium Alloy T4**, A. M. Yakimova, pp. 100-107.

The work is a continuation of the investigation of the influence of hydrogen on the properties of six-component titanium alloys T3, T4, T6, and T8.

**Method of Measuring the Depth of a Coating by Means of Reabsorption**, V. A. Trapeznikov, pp. 137-139.

**SOVIET PHYSICS—SOLID STATE** (*Fizika Tverdogo Tela*). Published by American Institute of Physics, New York.

Volume 3, number 2, August 1961.

**Quantum Mechanical Derivation of Formulas for the Antiferromagnetic Resonance**, P'u Fu-ch'o, pp. 348-354.

With the aid of Green's two-time temperature functions, formulas were obtained elsewhere for the resonant frequency and the susceptibility tensor of the ferromagnetic resonance. These formulas can be used in a wide range of temperatures. In another paper it was shown that this method can be also applied to the theory of antiferromagnetic resonance. In this article we study this problem. The results obtained here can be used also in a wide range temperature.

**Long-Time Strength and Steady Creep of Polycrystalline Bodies**, A. N. Orlov, pp. 367-369.

A model is proposed in which the diffusionless growth of micro-cracks determines the time to rupture and the rate of steady creep.

**Temperature Dependence of the Conductivity of Lead Sulfide Layers at  $10^{10}$  cps**, V. G. Erofeichev and L. N. Kurbatov, pp. 436-438.

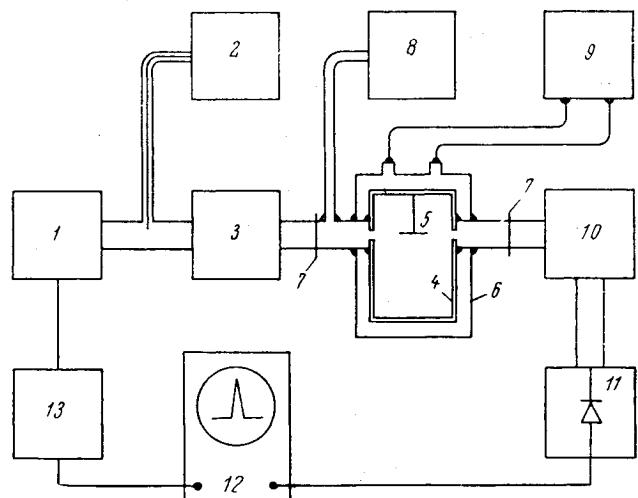


Fig. 1. The block diagram of the apparatus used to measure the temperature dependence of the conductivity at  $10^{10}$  cps. 1) An oscillator 43-I working in the 3 cm region; 2) an echo box; 3) a matching unit; 4) a resonator; 5) a lead sulfide layer; 6) a metal jacket for circulation of liquid oxygen or water; 7) mica windows used as vacuum seals; 8) a vacuum pumping system; 9) a thermostat TS-15; 10) a 3 db attenuator; 11) a crystal detector; 12) an oscilloscope EO-7; 13) a generator of sawtooth voltage signals.

The authors have shown that the electrical conductivity of lead sulfide layers at room temperature is several tens of times greater in the microwave region than the d.c. conductivity. The permittivity of the layers at  $\nu = 10^{10}$  cps was 500-1000, which is considerably greater than the permittivity deduced from the optical refractive index of lead sulfide monocrystals. These results can be interpreted by assuming that lead sulfide is an inhomogeneous semiconductor consisting of conducting crystallites separated by regions (layers) of low conductivity. The present paper describes a study of the temperature dependence of the electrical conductivity of lead sulfide layers at  $10^{10}$  cps.

**Features of Development of Destructive Fractures in Solid Polymers**, M. I. Bessonov and E. V. Kuvshinskii, pp. 445-447.

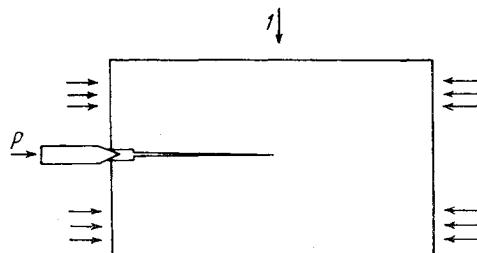


Fig. 1. Diagram of the experiments using "controlled" destruction. 1) Direction of observation.

It is well known that in metals and crystals the growth of destructive fractures is complicated by the emergence of localized plastic deformation. Until now it has been assumed that in solid polymers destruction proceeds in the way predicted for a perfectly brittle body and that no localized modifications of the material occur. However, data have been published which showed that this hypothesis was incorrect. From references cited it follows that the growth of destructive fracture in polymers ought also to be accompanied by the formation of a considerable amount of localized deformation, which in turn should naturally lead to complication of the destruction process.

We studied the microscopic growth and structure of destructive fractures in polymethylmethacrylate with 6% of dibutylphthalate (organic glass). Toward this goal, we used the method of "controlled" fracture which permits one to produce a single, slowly moving, planar destructive fracture. A diagram of the experiment is shown in Fig. 1.

Volume 3, number 3, September 1961.

**Mechanism of Brittle Rupture of Metal Crystals**, L. A. Kochanova, E. D. Shehukin and V. I. Likhtman, pp. 656-661.

We have determined the conditions of development of cracks in metal crystals subjected to deformation and determined the roles of shearing and normal stresses in the process of brittle rupture on the basis of the concept of heterogeneities of plastic deformation and of the stress concentrations resulting from these heterogeneities. We have measured the size of the cracks in amalgamated zinc monocrystals subjected to different degrees of deformation (elongation); the results obtained are in good agreement with the theoretical mechanism proposed. We have studied the appearance of the breaks resulting from brittle rupture of amalgamated zinc monocrystals; we explain their appearance on the basis of the predominant roles played by edge and screw dislocations in the formation of cracks.

**Discontinuous Character of Plastic Deformation at Low Temperatures**, I. A. Gindin, B. G. Lazarev, and Ya. D. Starodubov, pp. 669-673.

We have obtained deformation diagrams (compression, elongation) at 1.4-77 K for a large number of metals with different types of crystal lattices. We have shown that the plastic flow of all the metals investigated has a discontinuous character. The character of discontinuous flow at low temperatures is different for different metals and is caused by the difference in the nature of the jump-like deformation. We have classified the jumps and investigated the regularly increasing jumps of relaxational origin in greater detail.

**Volume 3, number 4, October 1961.**

**Determination of Certain Semiconductor Parameters From the Photoconductivity Spectral Response Curves**, V. A. Petrushevich, pp. 920-922.

A new method for determining recombination constants and absorption spectra from the curves of the spectral dependence of photoconductivity is developed.

**Volume 3, number 5, November 1961.**

**Radiative Recombination of Holes and Electrons in PbS, PbSe and PbTe**, N. S. Baryshev, pp. 1037-1038.

The temperature dependence of interband radiative recombination in semiconductors of the PbS group has been studied on the basis of the Van Roosbroek-Shockley theory. Thermal equilibrium recombination rates and lifetimes of excess electrons and holes were studied over the temperature interval from 77 to 522 K. The effective recombination cross section turned out to be practically constant above room temperature; values of  $1.3 \cdot 10^{-19}$ ,  $8.1 \cdot 10^{-21}$  and  $2.2 \cdot 10^{-19}$  cm<sup>2</sup> were computed for PbS, PbSe and PbTe, respectively.

**Volume 3, number 6, December 1961.**

**Theory of an Electron Plasma in a Magnetic Field. Effect of the Coulomb Interaction on the Magnetic Susceptibility**, A. G. Mironov, pp. 1200-1206.

The method of causal temperature-dependent Green's functions is used to investigate the behavior of a nondegenerate electron plasma in a constant magnetic field. The effect of the Coulomb interaction between the electrons on the Fermi branch of the energy spectrum is examined. The contribution to the magnetic susceptibility of the plasma caused by the Coulomb interaction is found.

**Theory of a System of Interacting Fermi Particles**, R. A. Suris, pp. 1303-1313.

A system of interacting fermions with  $\frac{1}{2}$  spin is studied by the method of Green's temperature functions. It is shown that for systems in which repulsion forces between particles predominate, the simplest approximation for Green's two-particle function leads to the possibility of a spin-ordered state. Phase transitions between spin-ordered and disordered states are studied. As an example, the case of a very short-range interaction potential is considered.

**Microstructural Strains Due to Thermal Anisotropy**, V. A. Likhachev, pp. 1330-1336.

The heating or cooling of polycrystalline aggregates which are composed of grains whose thermal expansion is anisotropic results in the appearance of thermal strains of the second order. In the present work the order of magnitude of these strains is evaluated taking into account not only the thermal expansion but also the elastic constants of the material. The solution is given for all 32 classes of symmetry. For a 1-deg increase in temperature we can get microstructural strains which range from the insignificant 0.000666 kg per mm<sup>2</sup> for graphite to the very large, 0.254 kg per mm<sup>2</sup> for  $\alpha$ -uranium.

**SOVIET PHYSICS-USPEKHI (Uspekhi Fizicheskikh Nauk)**. Published by American Institute of Physics, New York.

**Volume 4, number 5, March-April 1962.**

**Possible Investigation of Relativistic Effects With the Aid of Molecular and Atomic Frequency Standards**, N. G. Basov, O. N. Krokhin, A. N. Oraevskii, G. M. Strakhovskii, and B. M. Chikhaev, pp. 641-673.

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Many papers have been devoted to the various theoretical aspects of the general theory of relativity. A detailed analysis of many effects of general relativity, the possible experimental verification of which is discussed in the present review, and many new interesting consequences which can be subjected to experimental analysis, are found in an article by Ginzburg. We therefore pay principal attention in the present article not to a theoretical analysis of relativistic and gravitational effects, but to the possibilities of setting up various experiments to study these effects, and also to a verification of certain cosmological hypotheses with the aid of new high stability molecular and atomic frequency standards.

**Optical Model of the Nucleus in the Light of Present-Day Data**, I. S. Shapiro, pp. 674-697.

The development of nuclear physics in the course of the past few years has led to many unexpected results which essentially change our picture of the structure of the nucleus and the dynamics of nuclear processes. Briefly speaking, we have seen the tremendous importance of collective effects which give rise to the appearance of qualitatively new phenomena.

The subject of the present survey is the so-called optical model of the nucleus, a model according to which nucleons are scattered by nuclei in almost the same way as light is scattered by a semi-transparent optical medium. The important thing here is just this semi-transparency of the nucleus since, on the basis of the data concerning effective cross sections for the interaction of free nucleons, one would have expected the nucleus to behave like a black body in scattering processes.

The optical model for the scattering of nucleons has been investigated by comparing the theoretical and experimental data, beginning approximately with the years 1953-1954, after the appearance of the papers of Feshbach, Porter and Weisskopf. Although certain important details, concerning which we shall have to speak later on, still remain unclear, one can hardly doubt now that the optical model of the nucleus correctly describes nucleon scattering.

In 1958-1960 there was published a series of experimental and theoretical investigations whose results appeared at first glance to be completely fantastic. We have in mind the experiments on elastic scattering by nuclei of complex particles—deuterons,  $\alpha$  particles,  $N^{14}$ ,  $O^{16}$ , and other nuclei. As a result of the progress of experimental technique, one succeeded in these experiments in obtaining detailed pictures of the angular distributions of the scattered particles and, in particular, the differential cross sections for scattering through large angles. A comparison of the results obtained with the theory showed that the scattering of these complex particles is well described by the optical model and, in fact, with approximately the same parameters as for nucleons. In other words, it appears that the nucleus is almost equally transparent for complex particles as it is for nucleons. This remarkable fact, if it should be confirmed by further investigations, has great importance for an understanding of the dynamics of nuclear reactions and, in particular, of reactions of the so-called direct type, which proceed without the preliminary stage of formation of a compound nucleus. The results described concerning the scattering of composite particles will be treated in more detail in the second part of this survey. The first part is devoted to a description of the present state of the optical model for nucleons.